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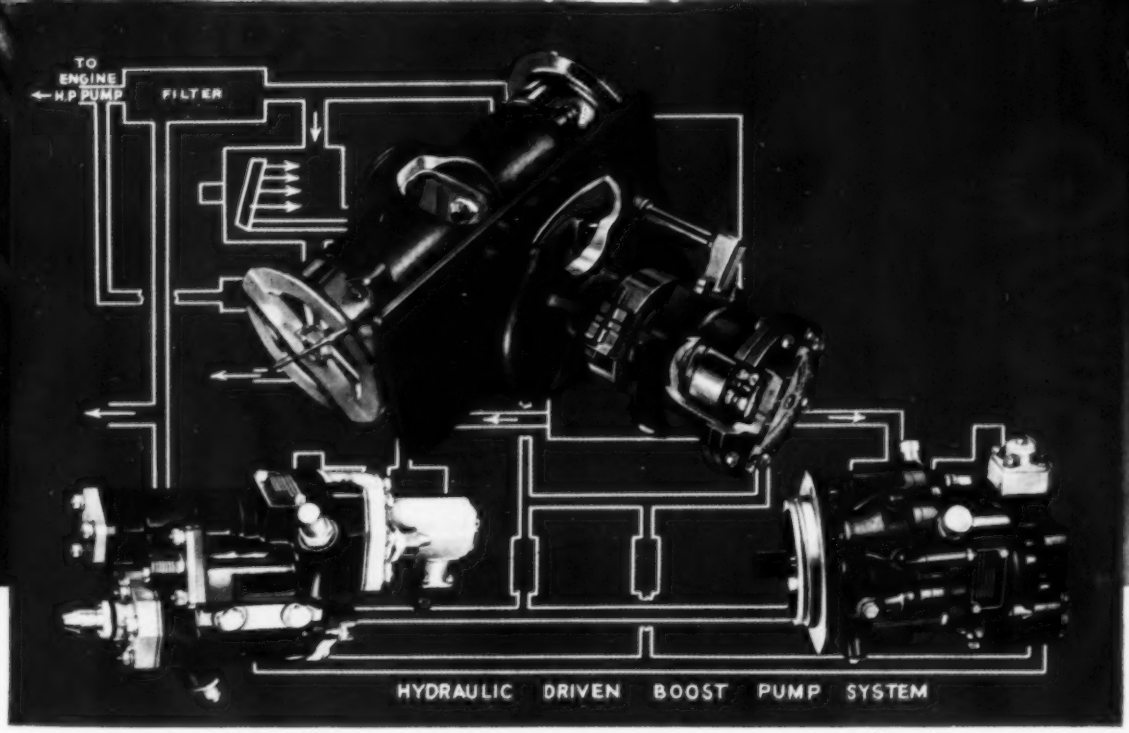

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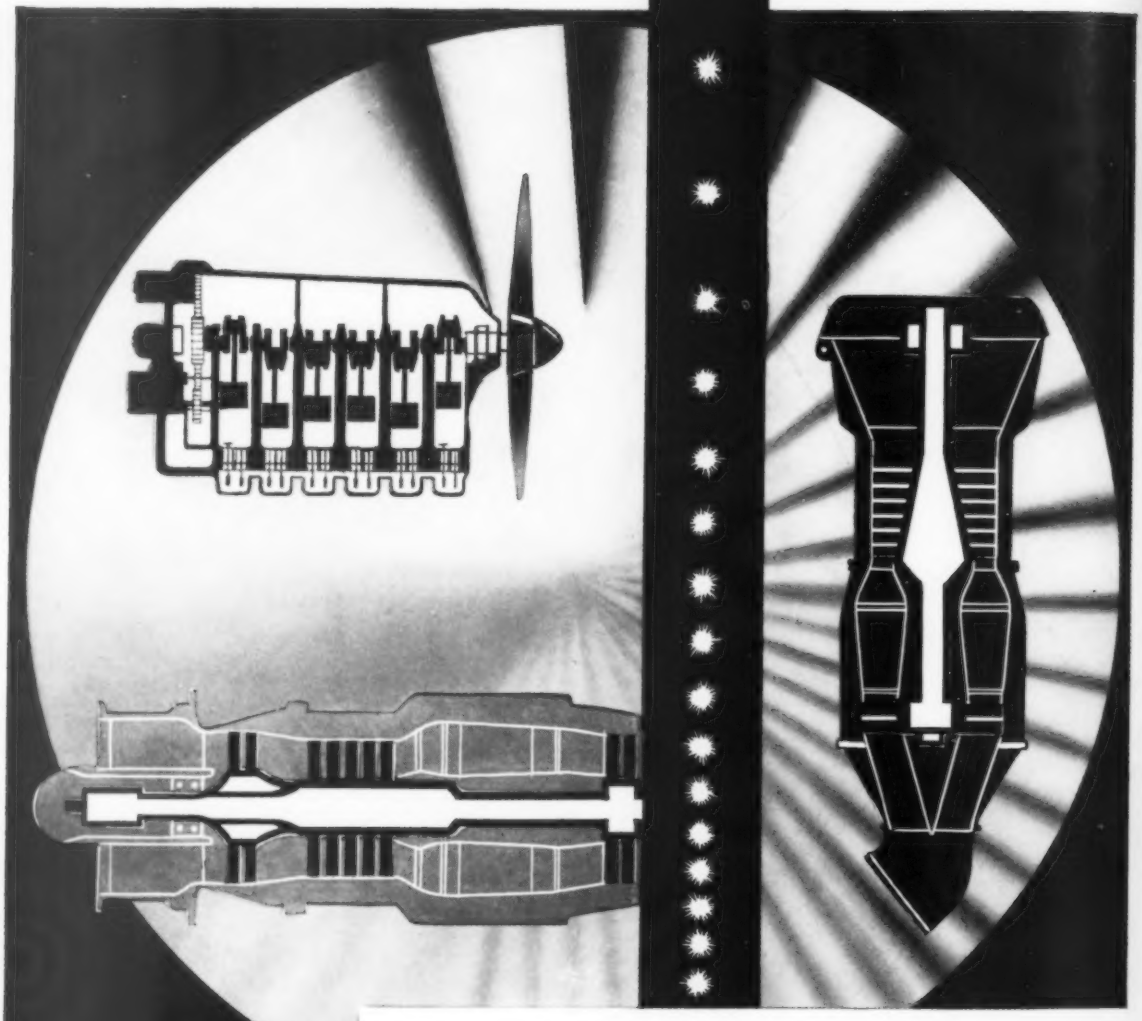

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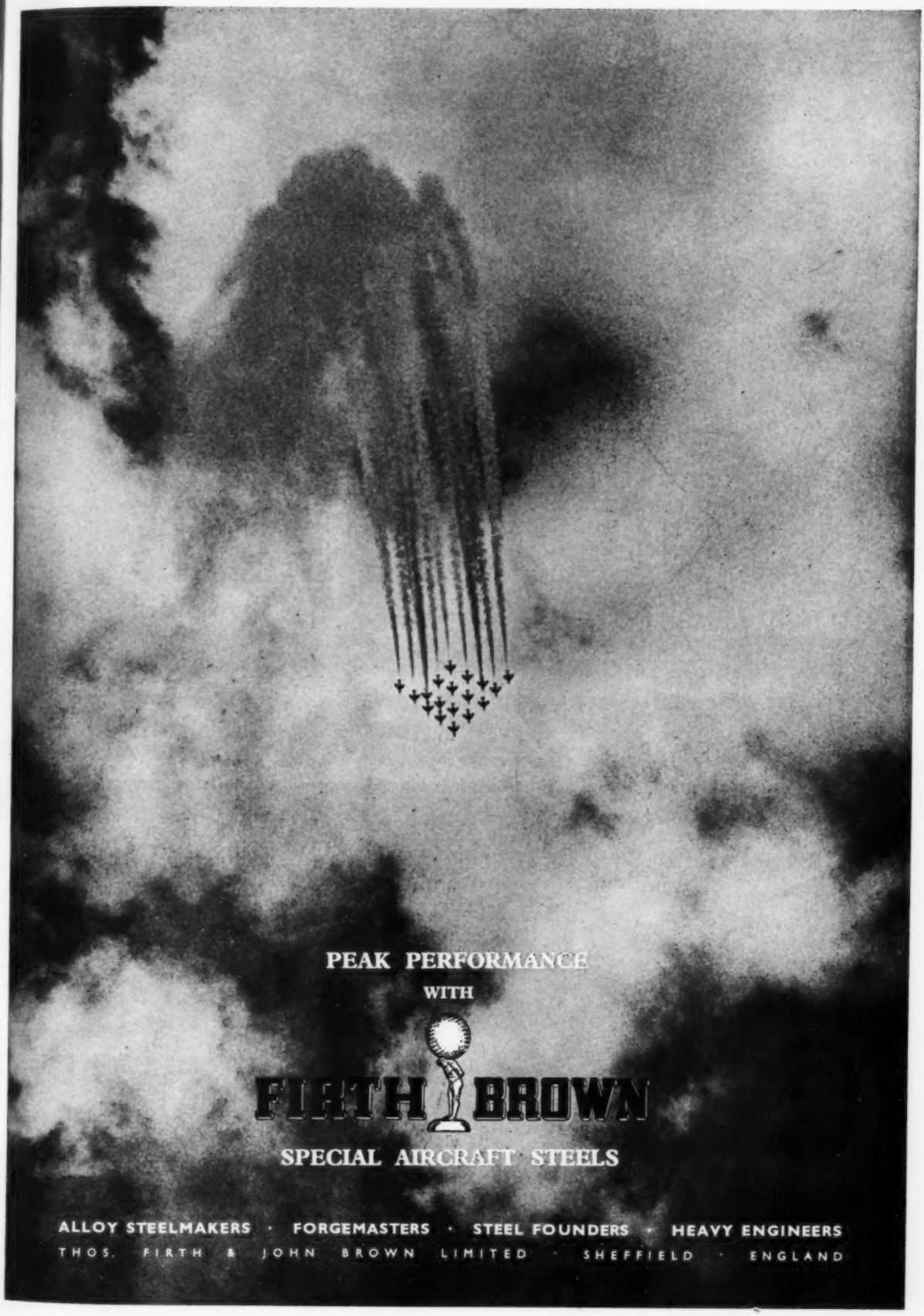
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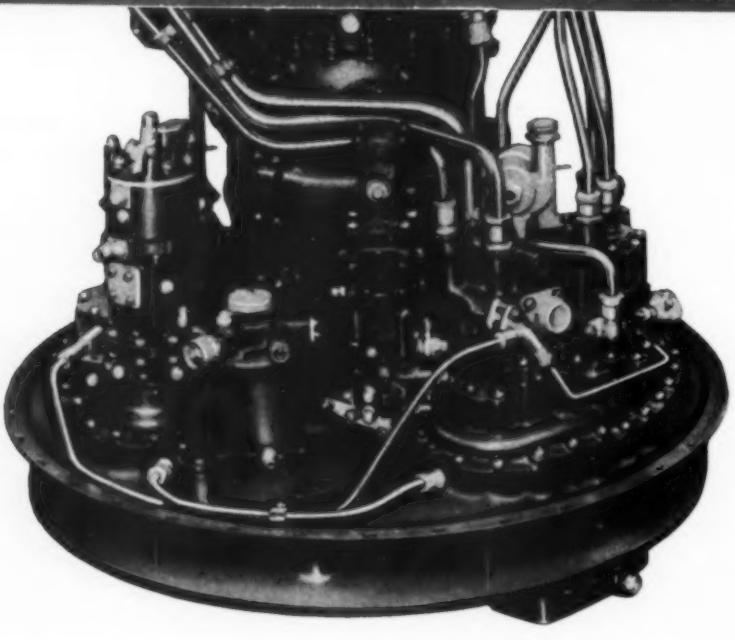

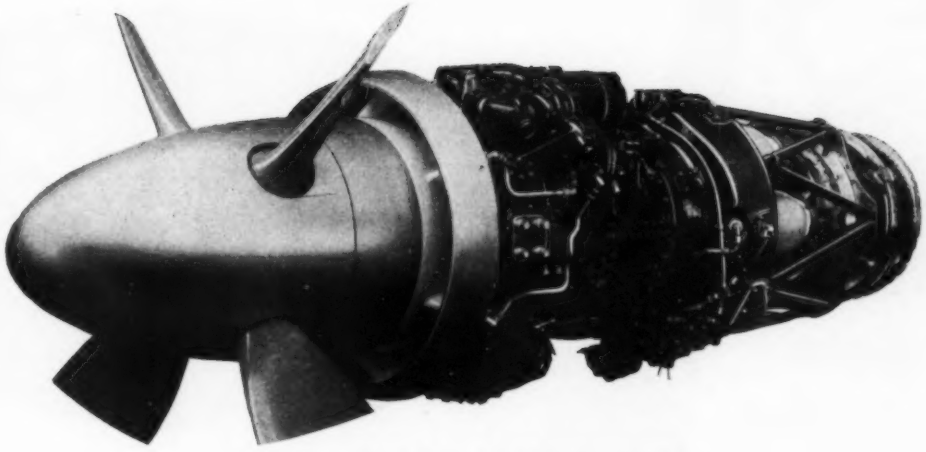

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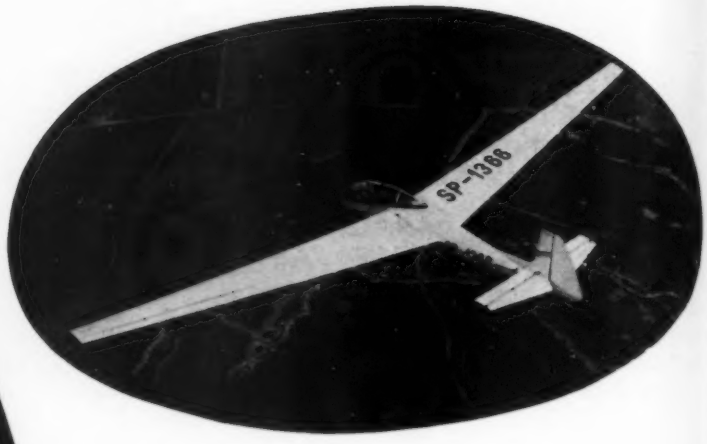

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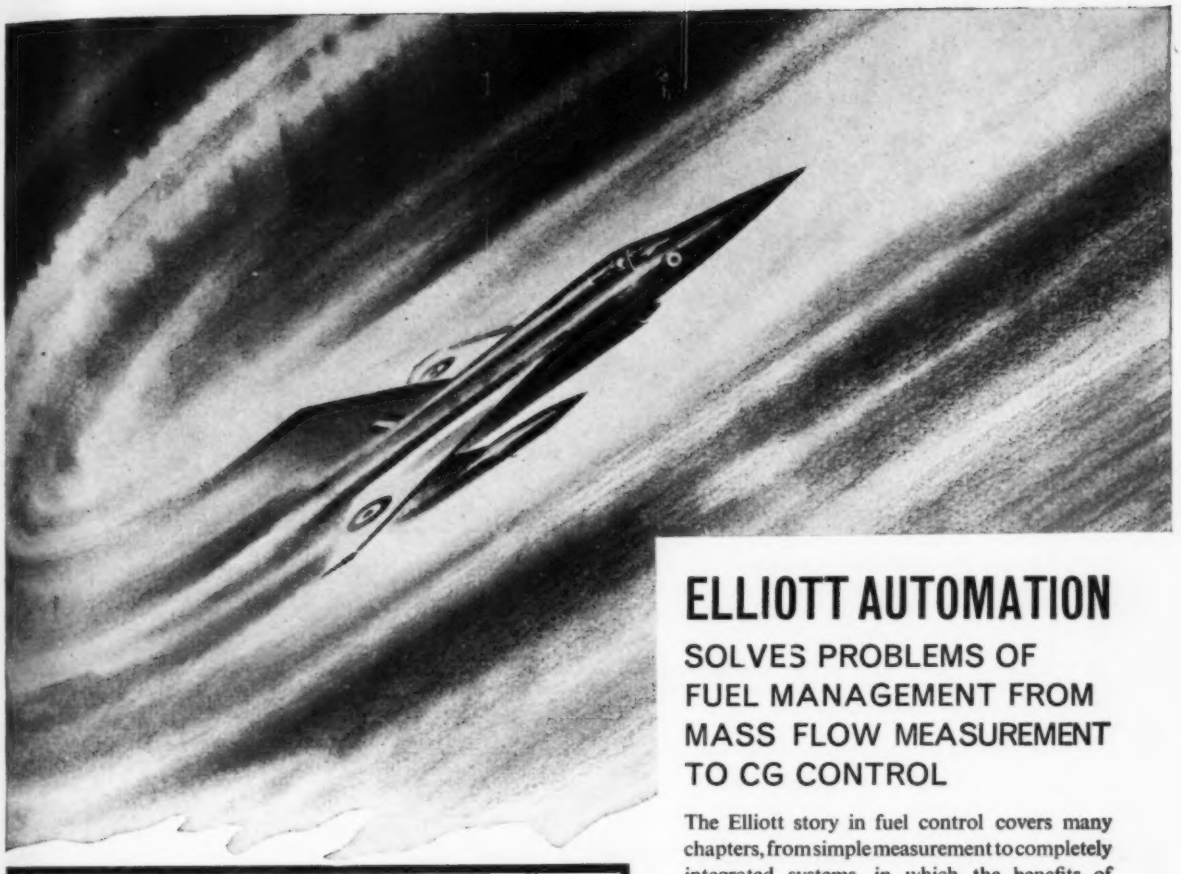

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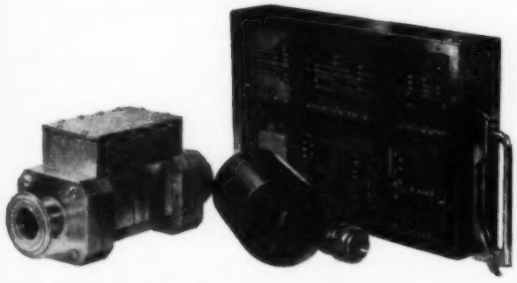

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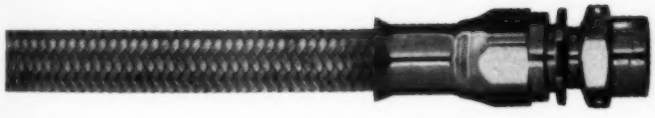

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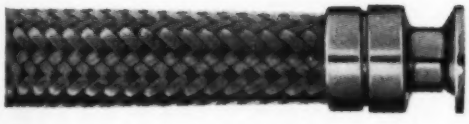

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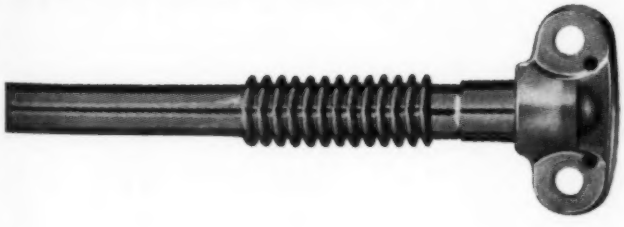

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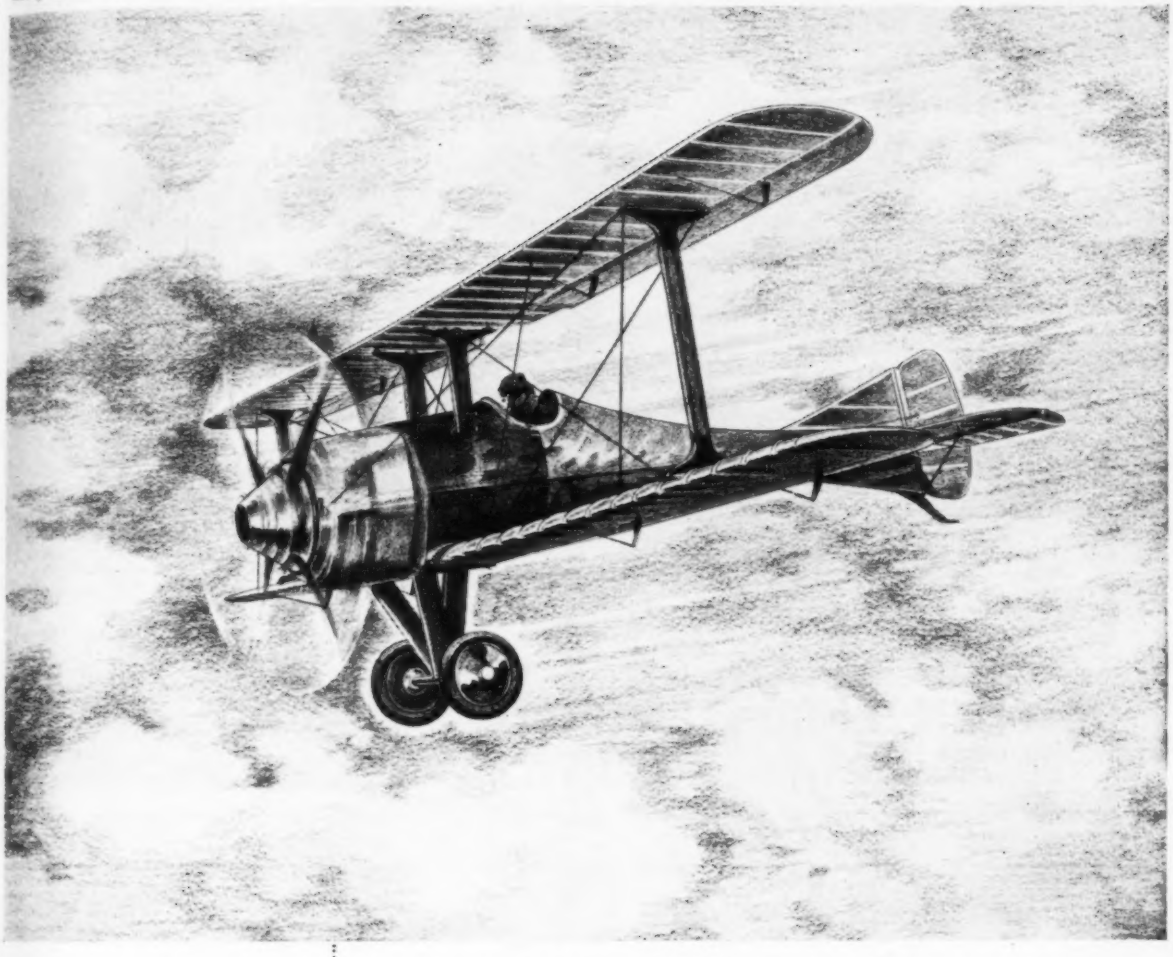

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(Answer given below)

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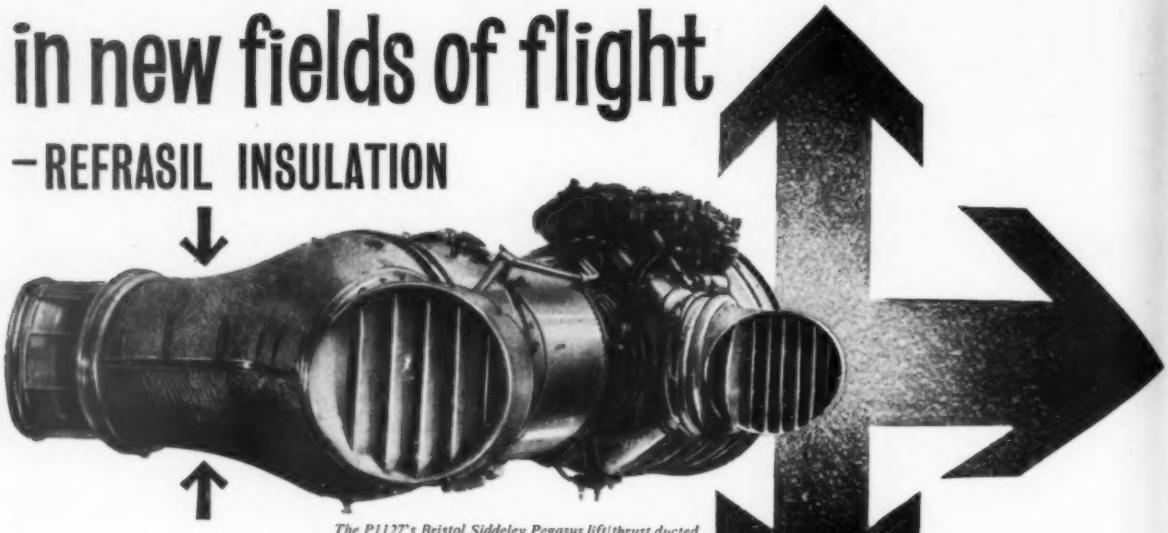

The P1127's Bristol Siddeley Pegasus lift/thrust ducted fan engine features movable jet nozzles for vertical or horizontal thrust. Note Refrasil blankets. (Arrowed.)

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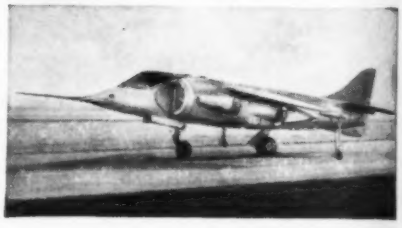

The Hawker P1127 experimental VTOL aircraft is fitted with Refrasil lightweight blankets.

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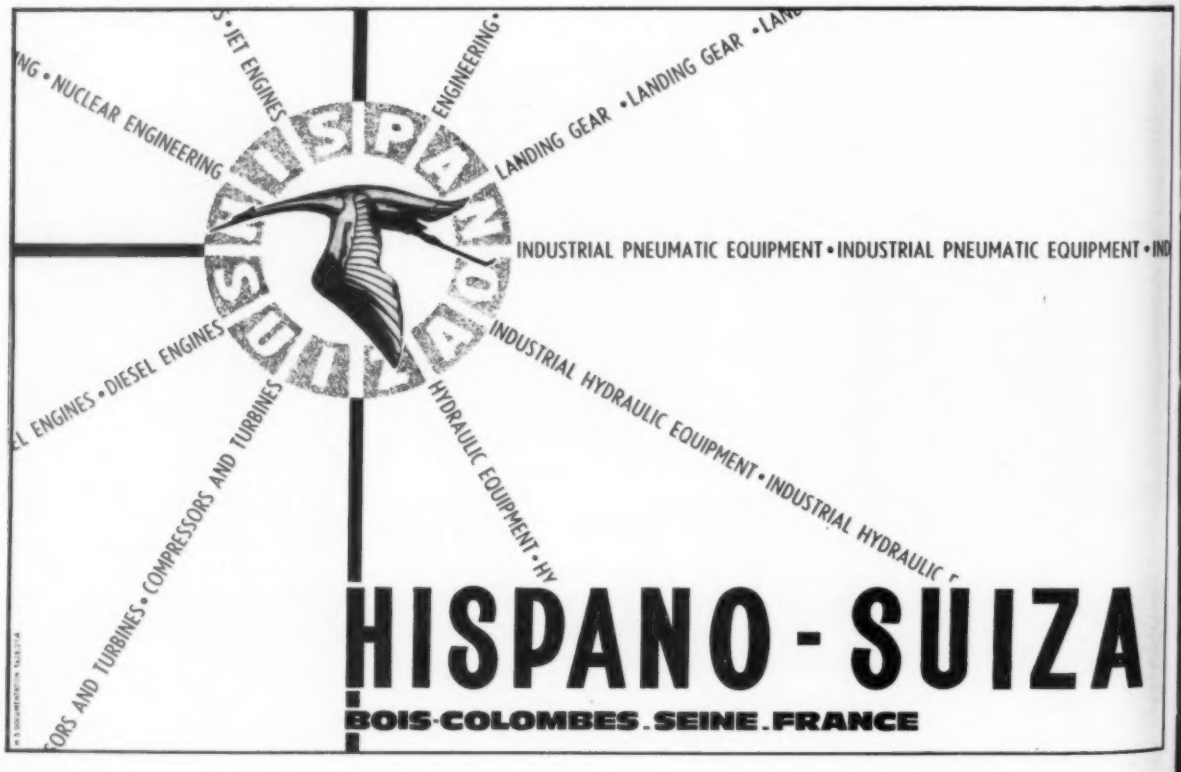
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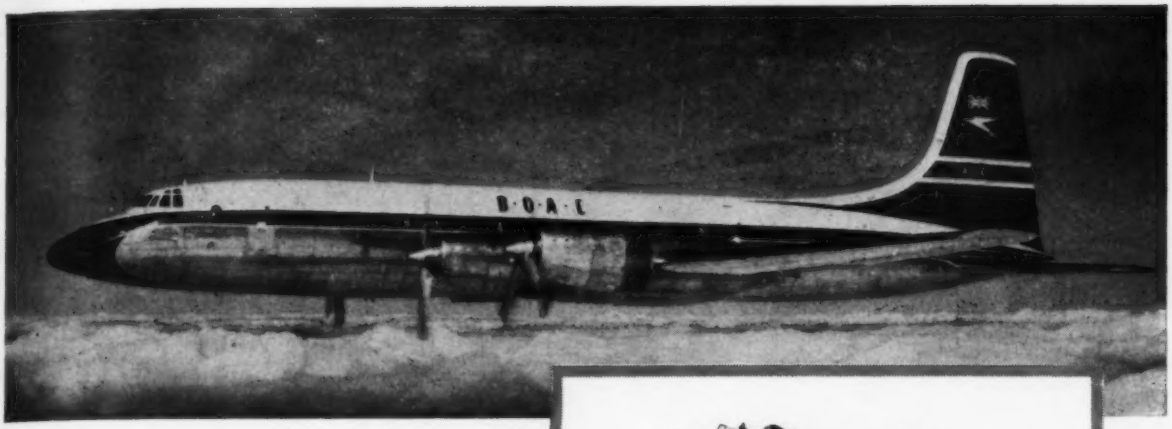

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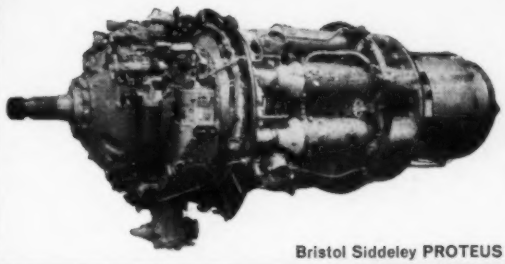

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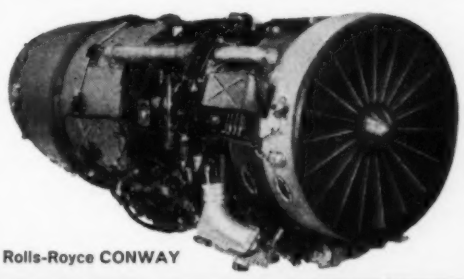

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Sorting Out Tushino

WE shall not apologize for reverting to the great Tushino display, our first appraisal of which, last week, was especially well received as we printed exclusively a clear ground view of Mil's giant flying crane. Among journalists, this sort of one-upmanship in the coverage of Soviet displays is pardonable, and adds a particular zest to life. The collation and interpretation of all procurable pictures and reports is a task that presents a very real challenge if readers are not to be misled by bogus identifications and entrapped by the pitfalls and labyrinths that beset intelligence work of this kind. Not the least of the hazards is in the conferring of designations. The NATO system of nomenclature, which provides much innocent merriment for East and West alike, is very well in its way, but invites abuses that can bedevil objective discussion. How many times in recent days one has heard such exultant cries as "See, the first photograph of a modified 'Fishpaste C'," or "I always *knew* that 'Basher' was really 'Bouncer' with a kinked trailing edge." An attempt to sort out the new Russian aircraft, while governing speculation with prudence, may therefore be helpful.

First, on page 98, we show an aeroplane which amazes by its inordinately —indeed fantastically—long nose. This type may be a long-range intercepter of extreme performance, and possibly the one which the Russians say is capable of "destroying any modern plane, whatever its speed and altitude." There exist, moreover, at least three varieties of delta-wing fighter, possibly by Sukhoi, and apparently differing in dimensions and powerplant. Such diversity is characteristic of the Red Air Force, just as the delta-wing-plus-tail and an affinity for under-fins is characteristic of Soviet designers.

Fitters, Backfins, Flashlights

The foregoing does not by any means complete the inventory of Russia's new fighters. In the same pictorial feature we have the first photograph of a type which seems to be NATO's "Fitter," together with a version of "Backfin," which may be a long-range fighter and not the supersonic bomber that the aircraft of this appellation was formerly considered to be. "Flashlights"—or members of this luminous family—were shown as all-weather fighters and multi-purpose aircraft; and there was a liquid-rocket-boosted Sukhoi (?) that disappeared vertically and is said to exceed Mach 1 on the climb.

Whatever Roger Bacon may imply in *Straight and Level*, these form a remarkable collection of fighting aeroplanes. The bomber picture has a highlight in the huge four-jet supersonic delta, approximating to "Bounder." We print a new view of this mighty aeroplane (which, as remarked last week, has evident potential as the prototype of a transport) on page 99. The great turboprop "Bear" seems almost archaic in contrast, though less so when it is reflected that these monsters passed over in strength, carrying massive stand-off missiles. Curiously, there has been no mention this year of the four-jet "Bison," so prominent in former displays, though "Badgers" were again observed in force, and with stand-off bombs. There is, too, the new bomber with twin jets *a la* Caravelle, which may be a near-relation of "Backfin," and unique jet-propelled flying-boats, glimpsed on page 98. Yet another "first" which we are able to present this week (it was tantalizingly absent from our first report) is Kamov's twin-rotor, twin-turbine counterpart of the Westland Rotodyne; and we are constrained to add that the monster Mi-6, already dubbed "Hook," is now seen to have as stablemate a true flying crane.

How aptly, through the eyes of Mahbub Ali in *Kim*, did Kipling view intelligence as a great game.

FROM ALL QUARTERS

Bloodhounds for the Swiss

ONLY a week after the announcement (page 32, last week) that the Bristol-Ferranti Bloodhound 2 missile had been chosen for the Royal Swedish Air Force, comes the welcome news that the same weapon is the subject of a major order from the Swiss Federal Government. Subject to ratification by the Federal Parliament, the order is estimated by Bristol Aircraft Ltd as being worth "between £25m and £30m." They describe this order as being "somewhat larger" than the Swedish contract of eight days previously, which was itself the largest export order then won by any British guided-weapon system.

It is significant that both orders have come from neutral nations, able to conduct full technical evaluation of all available equipment and under no evident financial or political pressure to buy from any particular country. Neither order for Bloodhound 2 is merely an evaluation quantity; both are bulk purchases of operational systems for inventory service. The Swiss weapons will probably be deployed by the Army, supplementing the indigenous Oerlikon-Contraves RSD-58, one of the first anti-aircraft guided weapons to be developed by any country. Export orders on such a scale are gratifying in themselves, in that they provide indisputable confirmation of the effectiveness and economic quality of our latest weapons; and, at the same time, they should significantly reduce the unit price, both for export and to the British armed forces.

Peter Brooks Joins Beagle

IT was announced last week that Mr Peter Brooks is to be appointed deputy managing director of the Beagle Group. He will take up the post as soon as his present duties as fleet planning manager of British European Airways can be concluded.

In his new position Mr Brooks will resume the close working association he had with Mr Peter Masefield during the years when the latter was chief executive of BEA.

Peter Wright Brooks, BSC(ENG), ACGI, AFRAES, is 41 years old and was educated at Chillon College, Switzerland, and City & Guilds (Engineering) College, London University. He obtained his "A" licence in 1938 and the A, B and C gliding certificates in 1939. From 1940-46 he served in the Fleet Air Arm as an operational pilot and test pilot, amassing 1,500hr on 80 types of aircraft. In 1947 he became a technical officer in the Ministry of Civil Aviation and in 1950 was appointed assistant to the chief executive of BEA, becoming technical assistant to the chairman in 1955 and fleet planning manager in 1960. Mr Brooks has published two authoritative books, *Evolution of the Airliner* and *The World's Airliners*.

PRINCESSES ALL FORLORN: This striking picture of two of the three Saunders-Roe Princess flying-boats laid up at Calshot was taken recently by Fairey Air Surveys. Final bids for the aircraft closed on June 30; a number have been received and are now being considered by the War Office (which is handling the disposal) in conjunction with the MoA

TURBO-CARIBOU: Chosen as the vehicle in which the General Electric T64 turboprop will first fly, this de Havilland DHC-4 Caribou prototype is now undergoing ground-running tests with its T64-4 engines. Flying tests are to begin during August

Bristol Siddeley Changes

A EUROPEAN headquarters is being established by Bristol Siddeley Engines Ltd in September to handle the company's rapidly growing Continental business. Its activities are to be directed by Mr R. L. Ninnes, special director responsible for technical services. He takes up his new appointment on October 1. Mr Ninnes has been a special director of Bristol Siddeley since its inception in 1959. He was chief development engineer and subsequently chief engineer (engines) of the engine division of the Bristol

Mr Ninnes

Brigadier Innes

Mr Blackwell

Aeroplane Co, before becoming technical services director of Bristol Aero Engines in 1955. Mr Ninnes is no stranger to Europe, having spent ten years with the Société des Moteurs Gnôme et Rhône (1925-35) and been a director of SECA in France and TABSA in Spain for nearly ten years.

Bristol Siddeley also announce that Mr B. D. Blackwell, deputy chief engineer, aero research and development, is to succeed Brigadier J. Innes (a special director) as business manager, aero. Mr Blackwell takes over this post on September 1. Brigadier Innes is to continue as a special director with special duties until the end of July next year—at which date, "to the company's great regret," he has expressed his wish to retire.

Return to Bristol

AN invitation to join the Bristol Aeroplane Company's board has been accepted by Mr C. J. Luby, MIPE, AFRAES, who has resigned as joint managing director of Dowty Rotol Ltd. Mr Luby served his apprenticeship with the engine division of the Bristol Aeroplane Co and in 1937 became first works manager of Rotol Airscrews Ltd (later Rotol Ltd), where he was largely responsible for setting-up the factory which subsequently manufactured and supplied many thousands of propellers and other aircraft ancillary equipment during the Second World War. He returned to the Bristol Aeroplane Co in 1942 as works manager (experimental department). In 1951 he went to Canada, becoming president of Canadian Steel Improvement Ltd. He was invited to join the Rotol board in 1956 as assistant managing director and two years later was appointed managing director in succession to Sir John Evetts, who became chairman. After Rotol had been acquired by the Dowty Group in 1960 a new subsidiary was formed to integrate the group's aircraft equipment interests and Mr Luby was made joint managing director, a position he held until his recent resignation.

Mr A. S. Bishop

IT is with regret that we record that Mr A. S. Bishop, formerly chairman of the Goodyear Tyre & Rubber Co (Great Britain) Ltd, died suddenly on July 10 at the age of 69. After his retirement as chairman in January this year he remained on the board as a director. In the aviation world he will be particularly remembered for his keen interest in the Goodyear Trophy races.

Mr Bishop had had a long connection with the Goodyear organization, dating from 1916. He was responsible in the early twenties for pioneering the giant pneumatic tyre in this country; in 1933 he became general sales manager and in 1936 sales director. He was made Goodyear (Great Britain) managing director in 1954 and became chairman in 1957.

Piston Provosts for Malaya

ALTHOUGH the piston-engined (Alvis Leonides) Provost has been out of production for a considerable time and has been superseded in the Royal Air Force by the Jet Provost, several air forces abroad are continuing to operate it. Ex-RAF piston Provosts are still in demand, and three were recently ordered for the Royal Malayan Air Force. Fully overhauled and reconditioned by Hunting Aircraft Ltd, they were flown out from Luton by three pilots of Airwork Services Ltd, T. P. Keegan, J. S. Weir and D. Thompson.

IN BRIEF

General Curtis LeMay was recently sworn in as Chief of Staff of the USAF. He succeeds General Thomas D. White.

Dr Terence Nonweiler of Queen's University, Belfast, was recently appointed to the Mechan Chair of Aeronautical Engineering at Glasgow University.

The first two Tu-16 "Badgers" which are replacing Il-28s in the Indonesian Air Force reached Djakarta on July 2. They were flown from the Soviet Union by Indonesian crews.

A first series of tests with the Breguet Alizés delivered to the Indian Navy was made recently from the aircraft carrier *Vikramp*, including catapult and non-catapult launchings and deck landings.

Mr James L. Anast, former director of the FAA Bureau of Research and Development, has been appointed Chance Vought Corporation's manager of European operations with headquarters in Paris. He was formerly president of Lear Corporation.

Rear Admiral P. D. Gick, OBE, DSC and BAR, is to be Flag Officer Flying Training from next October in succession to Rear Admiral F. H. E. Hopkins, CBE, DSO, DSC. Rear Admiral Gick's promotion from captain was announced recently (see page 76).

RAF Lightning pilots have been instructed to eject in the event of undercarriage failure rather than to attempt a wheels-up landing. In a recent case, Fg Off P. J. Ginger of Wattisham ejected after being unable to lower his wheels; his aircraft somersaulted when it hit the ground.

ASTRONAUT AT AIR MINISTRY: Maj Yuri Gagarin's visit to Britain, reported on page 70, included an Air Ministry reception on July 13. From the left, Mr Julian Amery, Lt-Col V. Konobeev (Soviet Assistant Air Attaché), Air Chief Marshal Sir Thomas Pike, Maj Gagarin

FLIGHT REFUELLING EXECUTIVE: Mr Michael Cobham, younger son of Sir Alan Cobham, who has been appointed deputy managing director of Flight Refuelling Ltd and chief executive under Sir Alan. He has been a member of the company's board for nine years

To commemorate the 50th anniversary of the first airmail in the United Kingdom—the London-Windsor service of September 9-23, 1911—the British Air Mail Society is arranging a golden jubilee exhibition and dinner in Windsor on September 9.

Air Cdre W. K. Stewart, CBE, AFC, BSC, MB, ChB, Commandant of the RAF Institute of Aviation Medicine, is to give the sixth lecture in the Guild of Air Pilots and Air Navigators series, at the Institution of Mechanical Engineers on October 12. His subject has not yet been announced.

A five-day course on noise measurement is to be held at the Royal College of Advanced Technology, Salford 5, Lancs, starting on September 11. It will stress practical measurement and familiarization with typical instruments. Details may be obtained from Mr Peter Lord at the college.

EYE-WITNESS AT TUSHINO

BY STEVENSON PUGH

AFTER five years in which comparatively few details have filtered out of the Soviet Union about the development of military aircraft we were given a surfeit in two crowded hours at Tushino Aerodrome in the Moscow suburbs on July 9. Even so, most of what we saw was shown fleetingly. Advanced types appeared along one of two laterally separated flight-paths; so it was pot-luck, according to one's position, whether one saw plan or profile. Confusion on the ground in Moscow that day prevented many from even reaching the show. I walked the last six miles through a traffic jam. Fortunately, apart from the helicopters, the meat of the show was in the second half.

Final assessments still have to be made. At this point I would suggest that the score of distinct new types shown publicly for the first time includes two helicopters, a convertiplane, a flying-boat, two fighters, two supersonic bombers and at least five air-borne missiles. In addition there were a number of apparent variants of known aircraft—particularly among the helicopters and fighters—which may well come to be classified separately.

The official programme announced "new helicopters of construct Milya M.L. and Kamov N.I." I saw these at a distance and there was what I took to be a development of Ka-18 "Hog" with a third, central stabilizing fin and one air/ground missile mounted on either side below the cockpit. In addition there was a much larger assault helicopter, apparently from the same distinctive stable, credited with capacity for 25 troops. The new Mils undoubtedly embraced the flying-crane development of Mi-6 "Hook" and a passenger version in Aeroflot colours which had, I thought, a deeper, longer fuselage faired back along the tail boom. American observers credited this with a capacity of 180 compared with 120 in Mi-6. But whether these latter two are to have new designations remains to be seen. The "Vintokrilya" convertiplane is much larger than photographs suggest, for the cabin windows are of unusual size compared with the head of a crew-member inside. I could detect no change of forward speed or noise suggesting that the twin rotors windmilled in cruising flight. Noise-level seemed remarkably low.

The military section opened with Mig-19 aerobatics followed by three Sukhoi 15 "Fishbeds" and five Mig 21 "Faceplates." It seemed to me that the operational aircraft shown in quantity of these two types which I saw more clearly thereafter were the larger Sukhoi 16 "Fishpot" and the previously unclassified "Fitter," which has larger wing area and cleaned-up tailplane compared with Faceplate. Both appeared in formations of 21, as did "Flashlight" in strike and intercepter versions. The latter two were described in the programme as supersonic—a word not otherwise used indiscriminately. Undoubtedly they were new production versions of the so-called "Flashlight C" and "B" prototypes which appeared at Tushino in 1956.

The new, twin-jet flying-boat, probably the long awaited Beriev Be-6 "Madge" replacement, had a slim high-speed hull with multiple shallow steps and a prominent spray-guard under the nose. Its wings had marked anhedral with tip-mounted floats. "Backfin" appeared twice: three vics in the general flypast, described as bombers, and a singleton in a final group described collectively as fighters. Backfin has been described previously as a Tu-16 "Badger" replacement. It seems to me more likely to be advancing the roles of "Flashlight B" and "C." The Tu-16 replacement unquestionably appeared in the remarkable flight of ten new supersonic medium bombers which followed a fly-past of 16 Tu-20 "Bears" and 15 "Badgers" (respectively carrying large and medium aerodynamic stand-off missiles). This new, impressively clean and graceful bomber is considerably larger than "Backfin." The external rear mounting of its twin jets indicates an uncluttered fuselage which could follow the example of Badger in development as a transport. The transport potential of "Bounder," credited with greater all-up weight than the B-52, goes without saying. "Bounder" was the vanguard of a last, frustratingly high-speed fly-past of types which have aroused more speculation than any other part of the show. They included the singleton, intercepter (?) "Backfin," "Flashlight C" (?), the new fighter, "Blinder" (?), two apparently differing large, twin-jet Sukhoi deltas and a Sukhoi 15 (?) with a rocket motor faired under the tail. So many question marks.... Even the designation "Blinder" seems out of place for an aircraft credited with being equivalent to the projected F-108. I expect the controversy to continue for some time yet. (One must agree; and the foregoing is welcomed as a contribution to discussion, as well as to knowledge.—Ed)

Rounding the Coventry pylon in true King's Cup winner style: Brian Iles in the Miles M.18 Mk 2. Above, Iles garlanded, holding the cup on which his name will be inscribed; with him are the second and third men home, the veteran Wg Cdr R. H. McIntosh (centre) and T. G. Knox

CHAMPIONS AT COVENTRY

RAF King's Cup Winner: Czech Wins Lockheed Trophy

"FLIGHT" PHOTOGRAPHS

AN RAF winner of the King's Cup, a Czech aerobatic champion and a whirlwind that swept destructively across the airfield —these were the headlines from Coventry Civic Aerodrome, Baginton, last weekend. The man who won the King's Cup, in a cream Miles M.18 Mk 2, was 35-year-old Sqn Ldr Brian Iles from Fighter Command; winner of the Lockheed aerobatic trophy was Jiri Blaha from Czechoslovakia, in a Zlin Trener; and the whirlwind which swept over Baginton last Friday was just part of the weather phenomena the air pageant organizers, Royal Aero Club officials and participants had to endure.

To tell the two days' weather story first. Friday was "unsettled, showery"—which meant in fact that Coventry lay in the path of a continuous succession of heavy showers moving from the south-west. This curtailed practice time for the King's Cup, because those competitors who got airborne found it difficult to locate the pylons in the rain while watching for other aircraft treading the same course; and it also held up the aerobatic finals.

The seven finalists—a Swiss, three Frenchmen and three Czechs—suffered agonies of delay from the weather's vagaries, because they met for a morning briefing, then again at 2 o'clock and finally at five. They did not, however, suffer the physical harm that befell two of the Lockheed judges, Sqn Ldr Turner Hughes and Bill Bedford, who happened to be in the judges' caravan, a substantial affair loaned to Lockheed, when the whirlwind struck. The caravan was overturned (this was the first time Bill Bedford had been VTO without the P.1127) and Sqn Ldr Turner Hughes had to have stitches put in his knee. The whirlwind also swung Peter Masefield's Chipmunk round, so that one of its wing-tips hit a refueller (fortunately the aircraft was repaired by Devonair in time for the King's Cup), turned Peter Vanneck's Tiger Moth up on its nose and had one of the picketed-down Turbulents airborne for a few moments.

When the Lockheed briefing was held at 5 p.m. the seven pilots went into camera and made their own decision to fly. It turned out to be the right one; for when the final started at 1830 there was a good ceiling and no rain: the only real disadvantage was a quite stiff breeze, which tended to blow the competitors downwind and petrified the spectators with cold. There was plenty to warm them up, however, in the performances.

Liardon in his yellow Jungmeister did not come up to his usual standard; he seemed to have difficulty in judging the wind and although he finished off superbly he may have lost a few marks through coming below the 320ft altitude. The real interest of the evening was in the difference in styles between the French and the Czechs. The latter, with their tough little Zlin Treners, had the edge in power and sturdiness on the French. Their specialization in flick manœuvres, sliding through the sky, tail-swishing, inverted climbs and bunting, gave their displays a crispness which made the Stampes and MS.350 comparatively slow and staid. This is not to denigrate the Frenchmen in any sense, and the judges gave second place to one of them, Gerard Jean Maurice Verette. Third came another Czech, Ladislav Trebaticky; then Francis Liardon (Switzerland), Jean d'Orgeix (France), Jaromir Hulka (Czechoslovakia) and Marcel Charollais (France), a fair distribution of honours.

In a comment to *Flight* about aerobatic training in Czechoslovakia, Jiri Blaha made the point that all flying training was free; the only obligation was to do 50 hours' flying a year. There was tremendous interest in aerobatics (the Zlin, he said, was stressed for 9g normally, 5g negatively) and next year a national competition was to be held. He expected there would be about 80 competitors. This seems to indicate an equally strong Czech challenge at Coventry in 1962.

Although the weather improved on the Friday evening, it was back to its old unsettled tricks on the Saturday, although the wind had veered in a northerly direction so there was a promise of better things to come. Briefing for the King's Cup was at 2 p.m., and while the 21 pilots crowded into a small room with the relevant RAeC officials a Victor roared past the windows to start the display.

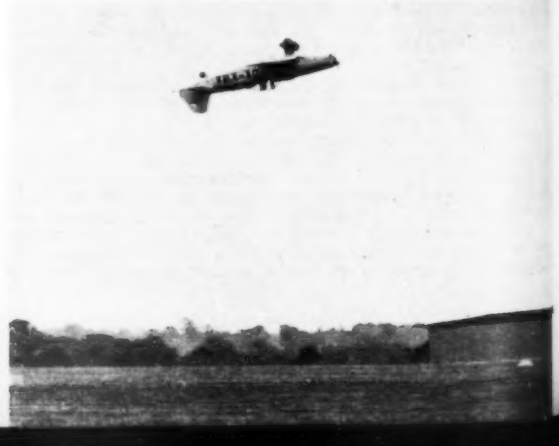
More than half the competitors elected to use Coventry's new runway for take-off, and Bellamy in his Mk 8 Spitfire had to sit on it for nearly twenty-seven minutes winding out his handicap time while the slower aircraft pounded round the course. It was not the Turbulents' year on this occasion, as in 1960; for Sqn Ldr Clive Francis, the only Turbulent pilot and first of the field to start, held onto his lead nicely for two laps then had to come down on the airfield with falling oil pressure.

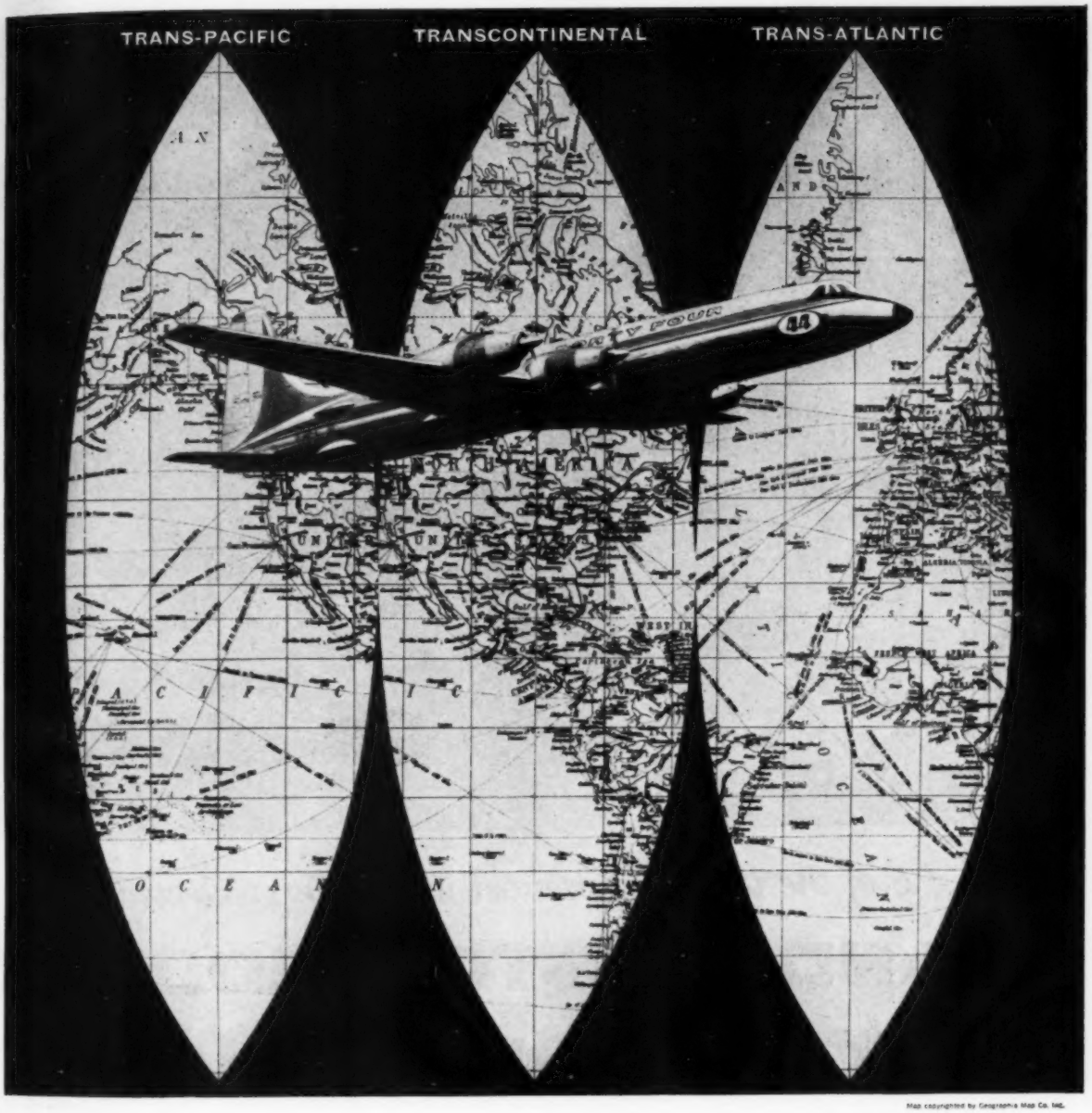
The big question was, could Bellamy do it? Or could Denis Hartas, in the Arrow Active, pull out that extra bit on the straight? What about Watson and Knox in the two Proctors? How would McIntosh fare, a 67-year-old in the only American machine in the race, a Cessna 175? And what about the Miles stable, the M.18, Hawk Trainer, Gemini, Falcon and Hawk Speed Six?

From the airfield, looking towards the east, there was a dull haze out of which the aircraft appeared low over the trees to round the Coventry pylon. After the first lap, the order was much that of

(*Continued on page 69*)

Jiri Blaha, aerobatic contest winner, wearing the victor's garland and holding the Lockheed Trophy (below); and at right in typical attitude during his Saturday demonstration. With him below, left to right, are G. J. M. Verette (2nd) and L. Trebaticky (3rd)





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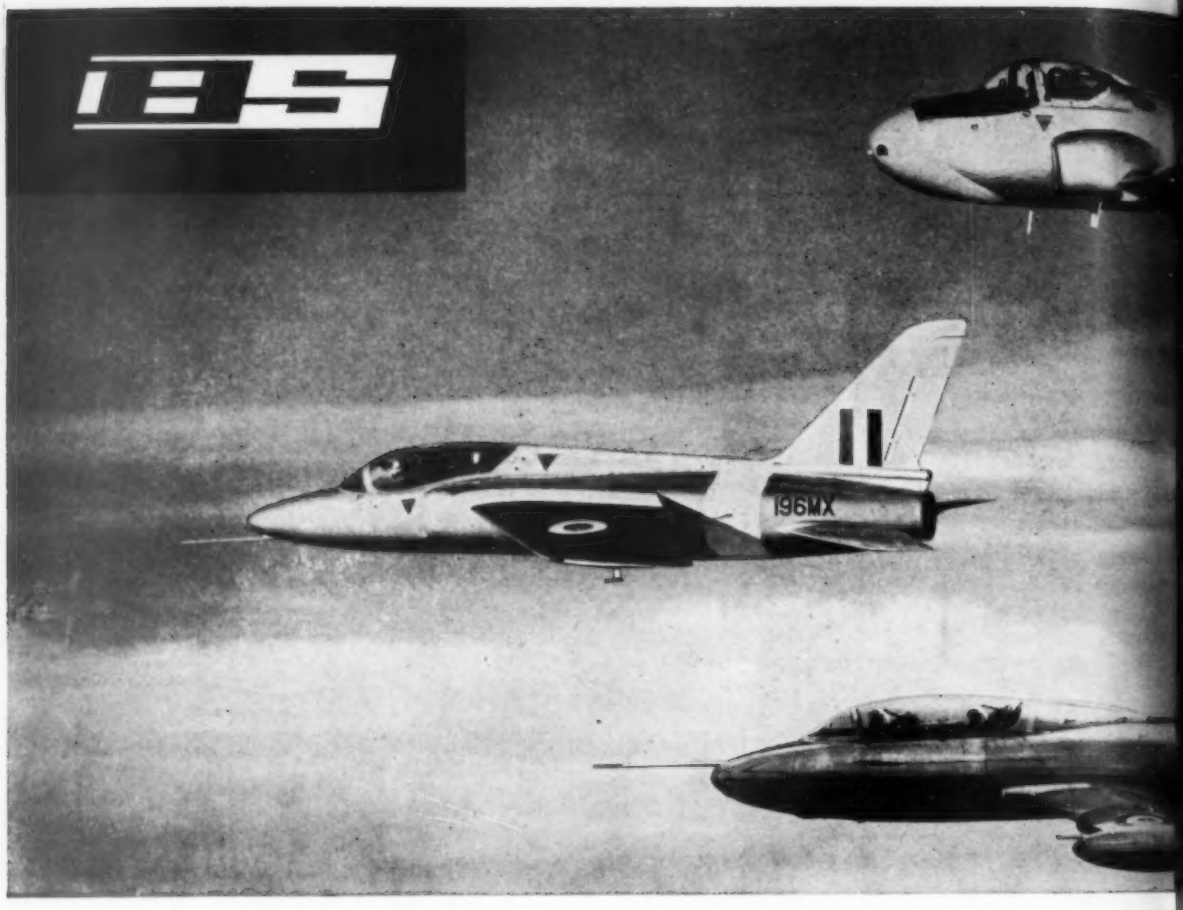

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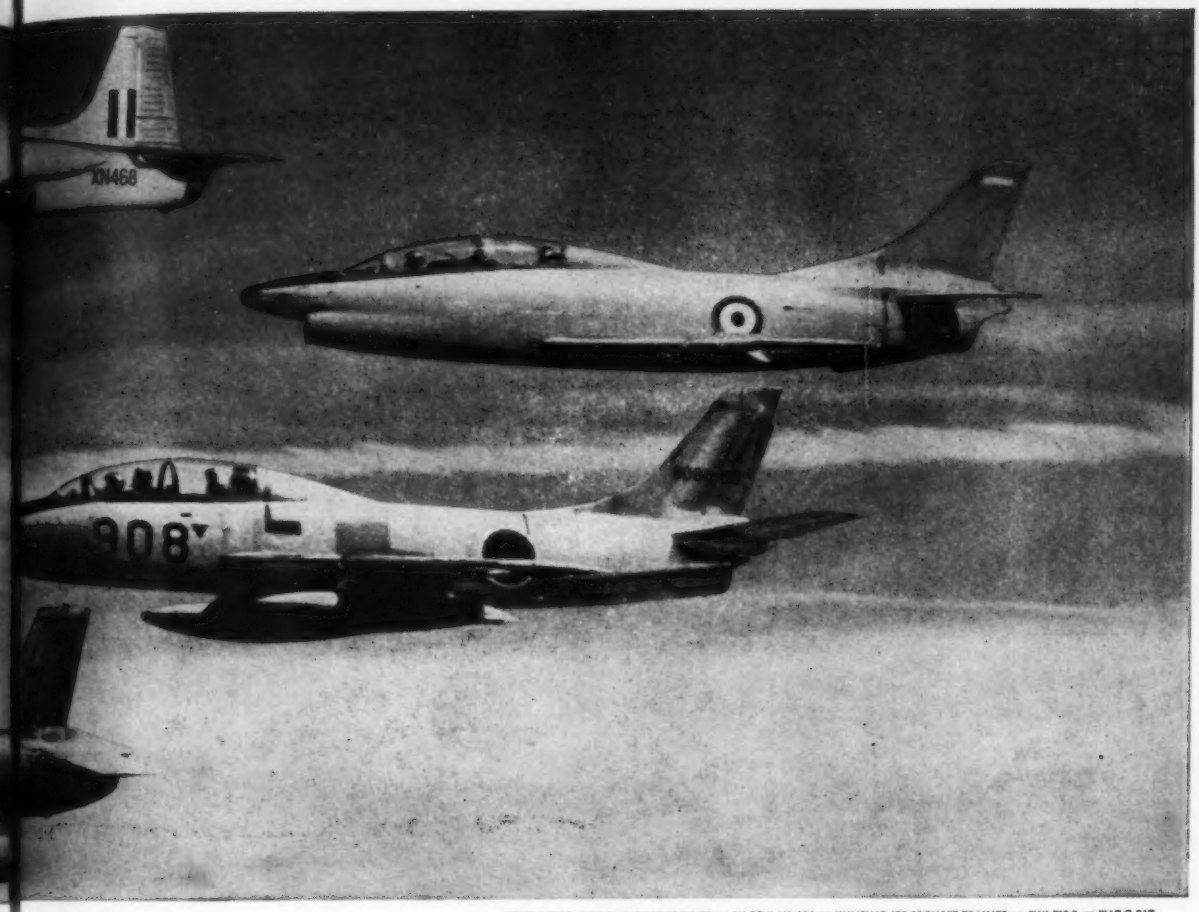
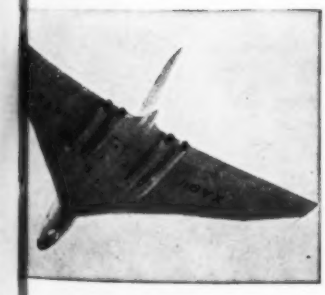


FROM L TO R: FOLLAND GNAT TRAINER — MACCHI MB 326 — HUNTING JET PROVOST TRAINER — FUJI TIF-2 — FIAT G 91T

... the forces of 5 countries ...

...SUPPLY THE POWER



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...ristol Siddeley Olympus high-thrust ...et powers the Avro Vulcan V-bomber ...ives this delta-winged deterrent car- ...n outstanding all-round performance. ...t Olympus versions deliver 20,000-lb ... dry. Even more advanced Olympus ...s are rated at 33,000 lb with reheat.

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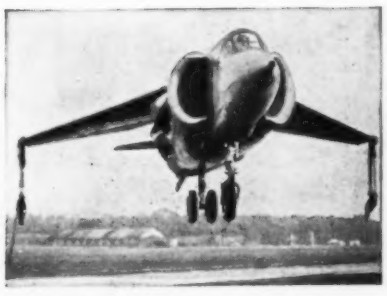
The Bristol Siddeley Proteus turboprop powers the Britannia airliner in service with 12 airlines and RAF Transport Command. The Proteus, which has now logged over 1¾ million flying hours, is famous for its reliability, for it reached the exceptional overhaul life of 2,400 hours more rapidly than any other aero-engine.



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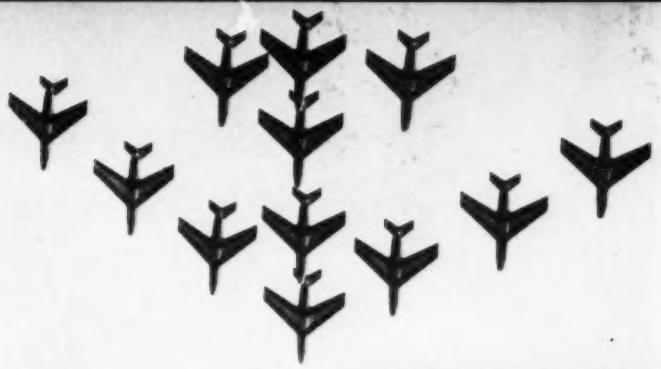
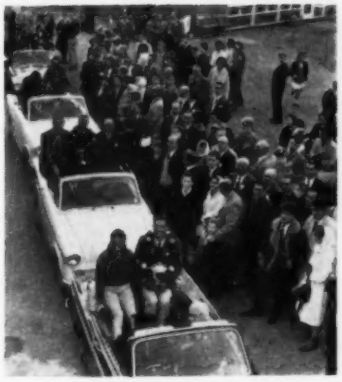


Above: Formation with French accent: the red-white-and-blue Mystères of the Patrouille de France at Coventry

Tiger duel (at left), as Rees takes a pylon on the inside of "Pee Wee" Judge



Victory cavalcade in Rootes Group cars: Iles and his passenger, Pat Peacocke; Knox, Aarons, McIntosh; Verette, Blaha; Flockhart and Bellamy

starting: Francis was still in front, followed by Jones and Vanneck then Sheila Scott in the Jackaroo, and the other two Tigers flown by Judge and Rees: the handicapping had not yet had time to show its effects, but already Trethewey, one of the other Tiger pilots, and Elton in the Archbishop Tiger, were having a tremendous duel. The Comper Swift, first of the faster fellows, appeared out of the haze, flown by Crowhurst, just after Percy Blamire had taken off in his beautifully kept Gemini 3C. Then came Iles in the M.18, Aarons in the Hawk Trainer, Hartas in the Active, McIntosh in the Cessna 175 and Masefield in his repaired Chipmunk.

When the little fellows appeared on their second lap, Blamire was well into the picture, in tenth position; close behind him was Marler in the Falcon 6. Then Ron Paine rounded the pylon for the first time in the Speed Six; behind him came Iles, Crowhurst, Aarons, Hartas and McIntosh—then Bellamy was off, with a familiar Merlin roar, at 1626½, after his long wait, and the field was complete. This was Lord Mountbatten's entry; last year the King's Cup had found a royal winner: what would happen this time?

Masefield came round again in his smart Chipmunk; then the two Proctors, Knox now leading Watson; then Blamire in his tawny Gemini; Marler in the Falcon 6; Paine in the Speed Six; Bellamy, turning the pylon higher than anyone else, his Spitfire's wings showing their beautiful shape: he had done his first lap in about three minutes—would he pull up 26min 50sec?

Still around the Coventry pylon it was the Tigers in the lead, Jones and Vanneck, with Francis in his Turbulent lying third; then came Sheila Scott, Rees, Gregory, Elton, streaking low across the airfield to the Hunningham turning-point. Trethewey in his Tiger (a previous winner, the only one in the race) had lost a lot of ground. Next was Iles, his M.18 looking white against the dull background. Then McIntosh, Aarons, Hartas. The field was beginning to show its final pattern and the handicap lead of the slower aircraft being whittled down. Round came Crowhurst in the Comper Swift, closely followed by Bellamy. Then Masefield, Knox, Watson—a good duel between these Proctors—with Blamire coming up over the horizon, followed by Marler and Paine. It was at this point that Francis had to drop out, making his precautionary landing on the airfield; then back came Bellamy, the Spitfire making a high turn over the field: he would have to put on the coal now if he were going to win. For a few minutes there was a pause charged with excitement; within seconds, the winner would appear out of the haze: it was clearly going to be a close finish.

Then, beyond the pylon, came the line-up for the final straight: and it was Iles, with a beautiful low run up the length of the runway, who was first home, having come up through the field on his last lap from tenth place into first. Then, breathing down the neck of the M.18, McIntosh in the Cessna 175; less than a shadow's length away, Knox in his Proctor—a good race he had flown indeed. Behind them, in fourth place, Bellamy: not even a lap speed of 298 m.p.h. had brought him home a winner. Iles's speed was 142 m.p.h., his time 40min 19.6sec; McIntosh did 145.5 m.p.h. for a recorded time of 40min 25.4sec and Knox 161 m.p.h., with a 34.8min time. It was a good finish, the whole field (less the unfortunate Francis) home within 80 seconds of one another: the kind of King's Cup finish one likes to see, and no doubt for Air Marshal Sir Richard Atcherley, on the control tower, it revived memories.

Unfortunately the number of spectators at Baginton for this year's event was limited by the uncertain weather. But those who came saw a splendid flying display—which included Nos 1, 2 and 3 in the Lockheed—in addition to the closely fought King's Cup.

There were three formation aerobatic teams—the Patrouille de France in their red-white-and-blue Mystères, the royal-blue Hunters of No 92 Sqn and the four Jet Provosts of the Central Flying School which split into pairs for synchronised manœuvres. It was interesting to compare the Patrouille de France and 92 Sqn displays—the former beautifully precise and guardsmanlike but somehow slower than 92's performance: the Mystères seemed to go away from the airfield for quite a long time while they got ready in the wings for their next presentation; with the Hunters, something seemed to be happening all the time.

There were also individual aerobatics, by the Wright Jubilee Trophy winner (Flt Lt D. Proctor) in a Vampire from No 5 FTS at RAF Valley, this aircraft doing particularly fine inverted outside turns, and by a Chipmunk of Birmingham University Air Squadron. The USAF did their usual refuelling demonstration with a KB-50, and fast passes by B-66, Voodoos and F-100s; the RAF put in a Canberra (in addition to the Victor); Handley Page a Herald, Beagle/Auster an Airedale (which Ranald Porteous gave an impressive outing to over the airfield) and the Army Air Corps an Auster and two Beavers, which dropped Sky Divers under coloured parachutes onto a marked square on the airfield.

This parachuting was the last event in the day; but the last word was with Alderman Mrs Pearl Hyde, chairman of the Coventry aerodrome committee, when she introduced the prizegiving by the Lord Mayor of Coventry, Ald William Callow.

At the prizegiving, in addition to those already mentioned, Viv Bellamy got the SBAC cup for the fastest lap and Sid Aarons received the RAeC Jubilee Trophy as the 1961 air racing champion. Ron Flockhart the racing driver got an award too—for his executive piloting.

H. W.

KING'S CUP AND CHAMPIONSHIP PLACINGS

P'n	Pilot	Aircraft	Regis'n	H'cap	Speed	Points		
				min/sec	(m.p.h.)	NAR§	KC	Total
1	H. B. Iles†	Miles M.18	G-AHKY	11 12	142	52	21	73
2	R. H. McIntosh	Cessna 175	G-APZS	12 05	145.5	44	20	64
3	T. Knox	Proctor 3	G-AIHD	14 56	161	34	19	53
4	V. H. Bellamy‡	Spitfire 8	G-AIDN	26 50	298	50	18	68
5	D. Hartas	Arrow Active	G-ABVE	11 40	142.5	46	17	63
6	S. Aarons *	Hawk Trainer	G-AIUA	11 27	141	58	16	74
7	C. E. Elton	Tiger Moth	G-ANZZ	06 35	121	46	15	61
8	P. Blamire	Gemini 3C	G-ALZG	17 11	174	54	14	68
9	G. Rees	Tiger Moth	G-AOUY	03 32	110.5	58	13	71
10	R. R. Paine	Hawk Speed 6	G-ADGP	19 25	191	54	12	66
11	G. Marler	Falcon 6	G-ADTD	17 26	176	44	11	55
12	P. G. Masefield	Chipmunk	G-AOTM	12 25	144.5	42	10	52
13	C. Gregory	Taylorcraft Plus D	G-AHGZ	04 39	113.5	48	9	57
14	P. B. R. Vanneck	Tiger Moth	G-APRA	02 29	107	42	8	50
15	I. Trethewey	Tiger Moth	G-AOAA	06 10	119	36	7	43
16	N. H. Jones	Tiger Moth	G-ARAZ	02 18	106	44	6	50
17	G. P. Watson	Proctor 3	G-AOEJ	14 37	155.5	64	5	69
18	Miss S. Scott	Jackaroo	G-APAM	02 48	106.5	32	4	36
19	J. W. C. Judge	Tiger Moth	G-ACDC	02 50	106.5	52	3	55
20	R. Crowhurst	Comper Swift	G-ABUS	09 44	129	36	2	38
—	C. P. Francis	Turbulent	G-ARIZ	00 00	Retired	32	—	32

*British Air Racing Champion. †Runner-up. ‡SBAC Challenge Cup for fastest aircraft. §National Air Races.

Missiles and Spaceflight

GAGARIN IN BRITAIN

The Gagarin smile, almost continuous throughout the major's visit to Britain, is here pictured on the occasion of the presentation of the British Interplanetary Society's Gold Medal in London on Tuesday, July 11

IN manned orbital flight, as in any other activity, there can only be one first occasion, and one first man. Even if this man insists that he is an ordinary mortal and not a superman, the greatness thrust upon him is there to stay. London recognized this on July 11 with a tumultuous welcome for Maj Yuri Gagarin, pilot-cosmonaut and Hero of the Soviet Union.

In the fashion theatre of the Soviet Exhibition at Earls Court, some 600 journalists and others attended a press conference on the afternoon of the major's arrival. So familiar had the smiling face of the astronaut become, through photographs, films and television, that it was difficult to realize that the orbital flight which launched him into the glare of world publicity had taken place only three months before.

This was the man. A short figure striding across the stage, wearing blue trousers, khaki jacket (appropriately medalled) and a likeable grin, almost hidden behind a massive spray of flowers. Acknowledging our applause in the Soviet manner by applauding in return. He was followed on to the platform by Soviet Ambassador A. A. Soldatov, chairman of the meeting, and a row of other officials.

First question came from the *Irish Times*. Did Maj Gagarin know whether he was to make further space flights? This had not been decided, the astronaut replied, but, as far as he was concerned, he would very much like to make further flights and he hoped he would be entrusted with them. Independent Television asked for details of the April 12 flight and further enquired whether the flight or the subsequent publicity had been the greater strain. It was difficult to say anything which had not already been said about the flight, we were told in reply; both flight and publicity were "very difficult" and anyone who wanted to know which was worse should try both. For the benefit of the BBC, Maj Gagarin stated that he had received invitations to visit many countries, but not the USA. In the near future he would be visiting Poland and Cuba, but he had his own work to do and it was important for him to pass on his orbital experience "since we plan to go in for space exploration on a big scale, in a big way."

Among the next "questions" came effusive greetings from the African Democratic Congress and from a gentleman from Cyprus.

Among those greeting Maj Gagarin at London Airport on July 11 was Air Marshal Sir Ronald Lees, Deputy Chief of the Air Staff (centre). At right is Mr Boris Belitsky, the major's efficient interpreter

The Japanese section of the BBC wanted to know what personal thoughts had occurred to Maj Gagarin while in orbit. The astronaut could think personal thoughts at other times, came the reply; during the flight he naturally devoted his time to his work. The *Daily Sketch* asked whether, on his next space flight, the major would like the world to watch the attempt, for example by televising the launch? Declining to answer this question, Maj Gagarin answered instead one which had not been asked. In fact, he said, a colour film of the take-off and boost phase of his flight had been produced.

The Soviet astronaut went on to deal politely with questions about women in space, space fiction, his first impressions of England, the English language and his wife's reactions to the orbital flight. *Flight* enquired whether Maj Gagarin had remained in his cabin during the descent of the spaceship to Earth, or had used the pilot-ejection system. This was not the first time he had been asked this question, the major replied. As he said at his Moscow press conference, he had descended inside the spaceship, although it would also have been possible for him to eject.

Even if the London conference was not the first occasion on which the major had been asked this question, it was in fact the first occasion on which he had given (or been reported as having given) an unequivocal answer.

Odhams Press wanted to know whether, during his orbital flight, Maj Gagarin had been "an observer only." A man in a space flight could not be an observer only, came the reply; he was bound to take an active part in the flight and in fact to direct it, and this was the job Maj Gagarin had carried out. What had been the results of the major's hospital checks, asked the *Daily Sketch*. In a number of medical check-ups, no changes in the astronaut's organism, either physically or mentally, had been found. He therefore assumed there were no ill-effects. Back into the arena of psychological after-effects came the *Daily Mail*—did the major have nightmares in which he re-flew the *Vostok* in space? No, he never had anything like that. He slept quite normally, and he had never been much of a dreamer, anyway.

A Zürich professor representing a number of unspecified cultural magazines in South-east Asia asked whether Maj Gagarin had experienced "what in oriental countries we call eternity." The answer, as interpreted in a not-uncreative manner by Boris Belitsky of Moscow Radio, was a non-committal negative.

Only in answering the final question of the conference did Maj Gagarin change from polite good humour to a strong finger-shaking emphasis tinged with propaganda. Associated Television suggested that, after his April 12 flight and subsequent publicity, the major could never be the same man again. Maj Gagarin said he disagreed with any division of people into ordinary mortals and celebrities. He was an ordinary mortal in every way. "We in the Soviet Union have many people who have accomplished a great deal"—the number of his Gold Star medal was 11,175, which meant that 11,174 people before him had accomplished something very notable. Mr Kruschev, for example, had three Gold Stars and was a Hero of Soviet Labour. As for the discomforts of publicity, the pressure would surely ease when there were many astronauts—and then they all would be able to lead normal lives.

A further gold medal, the first to be awarded by the British Interplanetary Society, came Maj Gagarin's way at the end of the press conference. This presentation was made by Dr W. R. Maxwell, president of the Society, who said that the whole world could be proud of Maj Gagarin's achievement, since "men of all nations from the beginning of civilization have contributed to the knowledge which ultimately made it possible." The Society's gold medals would be awarded to those making the greatest contributions to astronautics, and the award to Maj Gagarin was not only a tribute to his own courageous exploit but also to the scientific and engineering achievements of his countrymen which had made it possible. The astronaut's reply floated out to us from behind a heaving group of photographers who had at last stormed and taken the stage.

Maj Gagarin's programme during his visit to Britain included an Air Council reception at the Air Ministry on July 13, and lunch with the Queen and the Duke of Edinburgh at Buckingham Palace on Friday, July 14. The major left London Airport on his return flight to Moscow on the following day, July 15.

At the Air Ministry reception the Secretary of State for Air, Mr Julian Amery, presented the non-smoking major with a silver cigarette box, and received in return a copy of Maj Gagarin's new book on his flight into space. Among those present on this occasion were Air Chief Marshal Sir Thomas Pike, Chief of the Air Staff; Ambassador Soldatov; and Maj-Gen I. P. Efimov, the Soviet Military Attache.

K. T. O.

Pictured during the July 9 display at Tushino, this Tu-16 Badger is carrying a winged, air-breathing missile externally. Superficially, the weapon appears to have the body and wings of Mace and the powerplant of Hound Dog. It has small, swept wings and horizontal tail, an underslung engine, almost certainly a turbo-jet, and a relatively fat body with several auxiliary intakes and a dark-coloured nose. The engine intake appears to be covered by a blanking plate which makes provision for a centrebody, like the covers fitted to Bloodhound engines. The bomber is the first of its type to be seen with a non-transparent nose, suggesting a large radar installation

MANNED MERCURY SHOT DUE

A second Redstone-boosted ballistic flight from Cape Canaveral by a Project Mercury capsule carrying an astronaut was imminent as this issue closed for press. Designated MR-4, this launch was planned to be similar to that carried out by Cdr Alan Shepard on May 5. Maximum height scheduled was 115 miles, and the spacecraft was to be nicknamed *Liberty Bell*.

In configuration, weight and major systems, the spacecraft is identical to Cdr Shepard's, but a number of design changes had been made—not because of failings in *Freedom 7*, according to the National Aeronautics and Space Administration, but because of the concept of concurrency adopted in the project. Most of the modifications were put into production more than a year ago.

An enlarged pilot-observation window replaces the two six-inch circular ports used in *Freedom 7*. Located directly above the pilot, the window is trapezoid-shaped, 19in high, 11in across the base and 7¼in across the top. It will be used as a navigational aid, its scribed reference lines enabling the astronaut to determine the attitude of the spacecraft and to hold the required 34° attitude for the firing of the braking rockets at the peak of the flight.

After firing the retro-rockets, the pilot will switch to a new system of manual control being flight-tested for the first time—the RSCS (rate stablization and control system). This is an electrical system for controlling the reaction jets used to manœuvre the craft, and is available as an alternative to the manual system as used by Shepard.

Other differences in the *Liberty Bell* craft include an explosively jettisonable side hatch, a rearranged instrument panel, new bearing rings at the glove connections of the astronaut's suit to permit 360° wrist action when the suit is inflated, improved microphones in the pilot's helmet, additional protective foam plastic in the head section of the contoured couch to reduce noise and vibration during powered flight, and a new lightweight life raft. Aerodynamic streamlining of the three-piece clamp-ring fairing between the spacecraft and the Redstone has been effected, and a slight change in launch angle, giving a flight trajectory one mile higher and three miles shorter, has been adopted.

The scale of the Orbiting Astronomical Observatory being built by Grumman for the National Aeronautics and Space Administration is indicated in this first photograph of the full-scale mock-up constructed by the company. Unfolded dimensions of the spacecraft are 14ft 11in × 17ft 10in, and total weight will be 3,300lb, of which 1,000lb will consist of the satellite's experimental payload

BOEING TO STUDY LARGE ROCKETS

The Boeing Company has been awarded a $100,000 study contract by the National Aeronautics and Space Administration's George C. Marshall Space Flight Center, Huntsville, to investigate the development of large rockets employing solid and liquid propellants. The vehicles would be in the Saturn/Nova class, capable of placing 50,000-350,000lb in a 300-mile Earth orbit.

In this work Boeing will draw on data obtained in three earlier studies on large solid rockets carried out for NASA by Aerojet-General, Grand Central Rocket Co and Thiokol. During the six-month study two families of vehicles will be studied; those with a solid first stage and a high-energy liquid second stage, and those with solid rockets for the first two stages and a liquid-propellant third stage. Liquid hydrogen and liquid oxygen are envisaged for the liquid upper stages.

DOUGLAS TO STUDY REBOUND SPACECRAFT

A $450,000 study contract "for developing orbital placement technique and engineering design specifications" for the Project Rebound spacecraft has been awarded by the National Aeronautics and Space Administration to the Douglas Aircraft Corp. Under Project Rebound, it is planned to place in orbit three inflatable balloon-type satellites, larger and more rigid than the 100ft Echo 1, by means of a single launch vehicle, for use in a passive communications satellite system.

The Rebound experiments will involve ground stations in Britain and France as well as in the United States. It is intended that six satellites will be placed in orbit, using two Atlas-Agena B vehicles, during 1963. The injection technique to be developed by Douglas will have as its aim the establishment of the satellites in a common circular orbit 1,500-2,000 miles high, with equal spacing between satellites.

SATURN CHOICE NARROWS

A short list of four companies has been selected by the US National Aeronautics and Space Administration to submit detailed proposals for the design, development and production of the Saturn S-2 stage, the largest rocket unit yet undertaken by American industry. The four companies are Aerojet General Corp, Douglas Aircraft Corp, General Dynamics Astronautics Division and North American Aviation, whose initial proposals were chosen from those of seven firms. NASA hope that one of the four will be selected and a contract signed by October 1.

The S-2 will be the second stage of the advanced version of Saturn which should be able to carry a payload several times greater than that of the initial Saturn C-1. It will be capable of launching the three-man Apollo spacecraft to escape velocity, and could be used for circumlunar flight. The stage will be powered by four J2 liquid hydrogen/liquid oxygen engines now under development by Rocketdyne, and will have an altitude thrust of 800,000lb. First flight of the advanced Saturn with an S-2 stage is expected to be late in 1964 or early 1965.

RCA TO WORK ON RELAY

As indicated in the statement by NASA administrator James E. Webb in *Flight* of June 22, Radio Corporation of America has been selected for contract negotiations to construct the Relay experimental communications satellite, with the overall aim of testing the feasibility of trans-oceanic telephone, telegraph and television

Missiles and Spaceflight . . .

communications using an active repeater satellite. The contract is worth $3.25m and will be negotiated and managed by the Goddard Space Flight Center. The RCA proposal was one of seven submitted to Goddard.

The Relay satellite will weigh about 100lb and its designed orbital altitude extends to some 3,000 miles. The satellite will be launched by a Delta vehicle from Cape Canaveral. As already reported, the British GPO and the French Centre for Telecommunications Studies have agreed to provide ground stations for the transmission of signals in connection with Project Relay.

RECORD ORBIT BY MIDAS 3

Using the "kick in the apogee" technique, the re-start ability of the Agena B second stage was employed to good effect in the Atlas-Agena launch of the USAF Midas 3 missile-detection satellite from Point Arguello, California on July 12. A 2hr 40min near-circular polar orbit at a height of no less than 1,850 miles was achieved by the satellite which, including the second stage of the launch vehicle, weighed 3,500lb and measured 30ft in length.

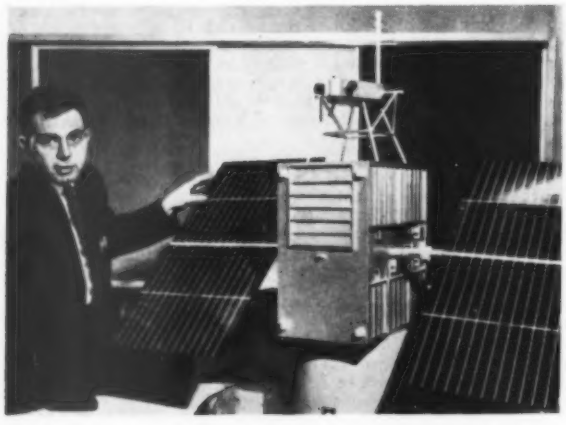
To test the satellite's infra-red detection equipment which is intended to detect the heat of rocket exhausts in missile launchings, it was planned to check Midas 3 in conjunction with planned firings from Cape Canaveral and Vandenberg Air Force Base. The July 12 launch followed an ignition failure on the pad on July 10, and earlier technical delays.

The proposed warning network envisaged by the USAF involves 8-12 Midas satellites in orbit around the Earth. Previous launches in the programme comprised that of Midas 1, which failed to enter orbit on February 26, 1960; and Midas 2, which achieved orbit on May 24, 1960 but suffered a radio failure which rendered the experiment inconclusive. The Agena B stage used on July 12 was longer and heavier than those used in previous attempts, as a result of increased fuel tankage. The height of Tiros 3 came as a surprise after the USAF had announced in advance that a 500-mile orbit was hoped for.

THIRD WEATHER SATELLITE LAUNCHED

In one of the two successful US satellite launchings on July 12, the National Aeronautics and Space Administration's Tiros 3 meteorological satellite was placed in orbit at 461–506 miles altitude by Thor-Delta vehicle from Cape Canaveral. The overall objective was to obtain television pictures of cloud formations and infra-red measurements of heat balance in the atmosphere, and to transmit both pictures and measurements to ground stations for meteorological analysis and limited operational use. In particular, it was hoped to study the origin and development of hurricanes, which are customarily numerous during the projected lifetime of the satellite. In orbit with an inclination of 47.8°, the satellite had an initial period of 100.4min.

Cylindrical in shape (measuring 42in in diameter and 19in high), Tiros 3 weighs 285lb and carries two wide-angle television cameras (unlike Tiros 1 and Tiros 2, which each used one wide-angle and one narrow-angle camera). Magnetic tape recorders are used to store up to 32 pictures during each orbit for transmission to Earth when the satellite is within 1,500 miles command range of a ground station. Improved remote-control programmers for the electronic equipment and new transistorized circuits in the electronic clocks which trigger the cameras are fitted. Other instrumentation, including beacon transmitters, attitude sensors, horizon scanners, telemetry circuits and a magnetic orientation control system, is identical to that used in Tiros 2.



As in Tiros 2, also, the satellite contains infra-red radiation experiments to measure Sun-Earth radiation relationships. Power for the operation of electronic equipment is provided by nickel-cadmium batteries charged by 9,260 solar cells. There are five radio transmitters; one for each of the two cameras, one to relay infra-red data, and two tracking beacons which telemeter satellite environmental data. The two primary ground stations are at Wallops Island, Virginia, and at the Pacific Missile Range, California.

The launching vehicle comprised a modified Douglas Thor as first stage; an Aerojet General liquid-propellant second stage; and an Allegany Ballistic Laboratory X-248 solid-propellant third stage. NASA's Goddard Space Flight Center has overall technical direction of the project, and the Astro-Electronics Products Division of RCA designed the television system and assembled and tested the payload. The Meteorological Satellite Laboratory of the US Weather Bureau will analyse the meteorological data, while the three infra-red radiation experiments are the responsibility of the Goddard centre and Dr Vernon Suomi of the University of Wisconsin.

The successful launch of Midas 3 by Atlas-Agena B from Pt Arguello on July 12 is reported on this page. This picture shows the unsuccessful launch attempt with the same vehicle on July 10. An extended Agena B stage was used and, on July 12, the second-stage engine was re-started successfully in flight, "kicking" the satellite into its 1,850-mile orbit

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Two new companies have joined the British Space Development Co Ltd, bringing the total number of member-firms to eleven. The newcomers are Elliott-Automation Ltd and C. A. Parsons & Co Ltd, and their representatives on the BSDC Technical Committee will be respectively Mr W. R. Thomas, joint general manager of Elliott Bros (London), and Dr H. M. Finniston, deputy research director of C. A. Parsons.

The 300lb re-entry capsule of the USAF Discover 26 satellite launched from Vandenberg Air Force Base by Thor-Agena B on July 7, was successfully recovered in mid-air north-west of Hawaii on July 9. A major objective of the launch was the systems evaluation of the Agena stage, emphasising the testing of recently changed components.

A multi-stage, solid-propellant sounding rocket was launched to a height of 50 miles from a site on the Mediterranean coast of Israel on July 5. A sodium-cloud experiment was used to obtain meteorological data. The rocket was designated Comet 2 and was stated to have been planned, constructed and fired by Israeli scientists and technicians.

The payload for the National Aeronautics and Space Administration's S-51 international ionosphere satellite (the first joint US/UK satellite, otherwise known as UK Scout 1) is being developed and built by Washington Technological Associates Inc of Rockville, Maryland. The NASA contract for this is for $84,450.

A contract worth $1,515,710 has been awarded by the National Aeronautics and Space Administration to General Electric Co of Philadelphia for the design and development of a stabilization and control subsystem for the Nimbus meteorological satellite and the supply of a "pre-prototype and a prototype."

Model of the Advent communications satellite, to be used in a joint Army/Navy/Air Force project to test the feasibility of microwave satellite communications. "Synchronous" orbits at 22,300 miles are planned

FLIGHT SYSTEM SURVEY

VGPI and Doppler VOR

THE first installation of the RAE-developed Visual Glide-path Indicator in America was commissioned on 13/31 runway at New York La Guardia late last month. Each end of the runway has been equipped with the full complement of 12 lights, made by Sylvania Electric Products Inc, and the installation cost $80,000. The two bars are placed 500ft and 1,000ft from the threshold. VGPI is, of course, now standardized both by the FAA and by ICAO.

First installation of another recently proved development, Doppler VOR, has also been completed—at Marquette, Michigan; and a second installation will be commissioned, on Rikers Island, New York, at the beginning of next month. Doppler VOR provides the same directional signals as normal VOR, but has a ring of 50 aerials mounted in a circle of 22ft radius on a metal counterpoise. The layout offers much greater freedom from site effects.

Finding the Eastern Wind

As part of the programme of technical assistance to CENTO countries the Government has ordered five Decca wind-finding radars of an improved model to be located along the main air route between Ankara, Teheran and Karachi. The radars will be able to measure winds at heights up to 100,000ft, meeting expected requirements for many years to come.

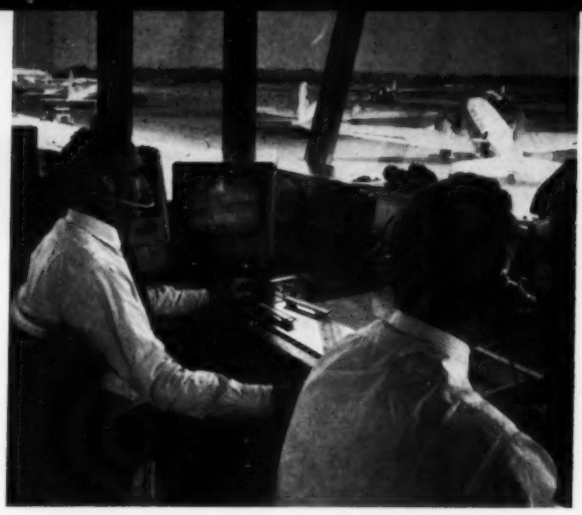
Decca have also received an order for type WF 2 wind-finding radar from the Government of Indonesia. This is part of a programme to provide accurate wind information over the whole area for both defence and civil aviation. Decca wind-finding radar is now being used by 34 of the world's meteorological authorities.

Pakistan Navaid Calibration

THE US has presented to Pakistan a DC-3 equipped for the calibration of aeronautical ground facilities. The aircraft was handed over to Air Cdre A. Qadir, Pakistan's Director-General of Civil Aviation, by the director of the US Operations Mission to Pakistan. Capable of calibrating VOR, ILS and other navigation aids, it should be of considerable benefit to PIA and other airlines.

Voispond

DURING a recent flight by a PanAm jet airliner from Sydney, a system called Voispond was used for the first time, to make automatic replies to radio calls from the ground without interrupting normal crew operations. Voispond incorporates a recorded identification message which is automatically transmitted on normal communication frequency whenever the controller on the ground presses a button and addresses a call to the aircraft. Satisfactory replies were received from Fiji and Auckland.



Air traffic controllers at Southend now have a Marconi closed-circuit television link with 14in monitor, shown here, by which they can watch a busy holding area and traffic intersection. The camera is mounted on the corner of a hangar and a second monitor in a weatherproof box is provided for lining-up

Texas Instruments Expansion

A SOLAR cell, Solid Circuit semi-conductor network and transistorized amplifier were used with a 15kV, 30mA current to cut the tape for the recent opening of the new 132,000 sq ft factory of Texas Instruments Ltd in Manton Lane, Bedford. The new works, which was opened by Sir John Cockcroft, Master-designate of Churchill College, Cambridge, is specially designed for transistor manufacture and also incorporates some new building techniques. Underneath the main manufacturing floor is a 10ft space-frame housing utility and servicing facilities, the outputs from which are fed into the main area through outlets at 10ft intervals. The floor was formed from concrete slabs cast at ground level round the pillars and hoisted up to actual floor level. Special thin hyperbolic paraboloid concrete shells form the roof of the manufacturing section.

The factory includes an office block and canteen and the gardens surrounding it are landscaped and planted with trees and flowering shrubs. External and interior aspects are illustrated on this page.

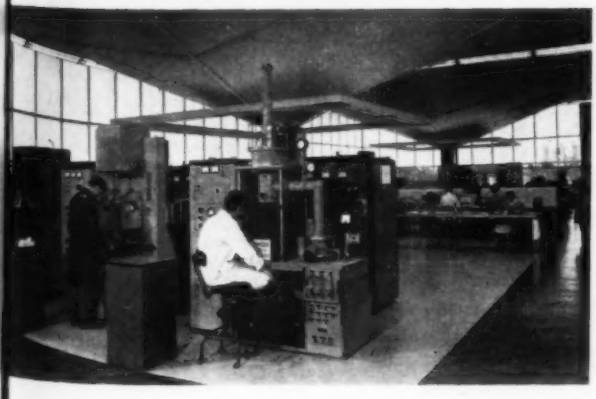
New Portable Nav Radio

THE Royal 790 Super-Navigator transistorized portable radio has now been announced by Zenith Sales Corporation in Chicago. It will receive broadcasts on 540 to 1,600kc/s, weather broadcasts and beacons on 150 to 400kc/s and certain other signals in the 2.0 to 5.0Mc/s bands. Automatic volume control can be disconnected and a beat-frequency oscillator switched on to make homing on standard aeronautical and marine beacons possible with an internal ferrite rod aerial.

The FAA maintains a considerable number of weather broadcast stations, some of which continuously transmit a local weather summary recorded on a tape which is changed every hour, or more frequently if weather conditions change rapidly. The Royal 790 weighs 5lb 6oz with batteries, is housed in a small leather case and is reported to cost $99.95 in the US. British agents are United Mercantile Co Ltd, Sovereign House, Queen Street, London W1.

Safe Flight Stall Warning

A RECENT report from Safe Flight Instrument Corporation shows that new orders are being received in considerable quantities for stall-warning systems and lift instrumentation for a wide variety of aircraft. Repeat orders have been received for the Grumman Gulfstream, Canadair CL-44 and Cessna T-37 and firm orders for 30 sets of precision stall-warning equipment have been received for the Avro 748. The BAC 111 is to be equipped, as is the Beagle Auster Terrier. Pre-stall warning equipment has been requested for a new but unnamed design by Avions Fairey in Belgium and Saab have requested a proposal for lift instrumentation for the J-35 Draken.



Texas Instruments' new 132,000 sq ft factory at Bedford is designed for production of semi-conductor devices. In the lower view is seen a machine for growing silicon crystals under closely controlled conditions. Note the hyperbolic paraboloid concrete roof formation

Straight and Level

SCRUGGS AIRCRAFT LTD
A Satisfactory Year Despite Difficult Conditions

AT the annual general meeting of Scruggs Aircraft Ltd at Ponders End on July 17 the chairman, Sir John Blackout-Jones, announced a net profit of £321 million for the year 1960-61. This was a drop of £12 million on 1959-60, but (said Sir John) it had been an exceptionally difficult year. A severe economic recession in the Ponders End district, an unfortunate setback to the Speedliner prototype (which melted during pre-flight engine runs) and regrettable Ministry reluctance to sign a £20 million contract for the development of a promising new microswitch had all tested the ingenuity of the firm's accountants to the utmost.

However, Sir John was glad to report that the morale of staff had never been higher, especially following the midnight explosion that demolished the works canteen in February.

Continued efforts to obtain production orders had been made, and though no sales had actually been achieved, a record number of brochures and copies of *Scruggs Heritage* had been distributed.

A splendidly luxurious new £100 million office block for the ever-expanding team of Ministry resident technical officers and Treasury officials had been built, and had provided most agreeably congenial accommodation for sometimes rather difficult meetings and contractual negotiations. It had been jokingly nicknamed the Costplus Hotel.

Sir John warmly praised all Scruggs staff for their loyal support throughout the year under review. The year ahead would not be an easy one, and the board had reluctantly decided not to recommend a dividend. But Scruggs' place in the forefront of world aviation was assured.

● Major Gagarin's place in history is assured. He showed us last week that it takes longer to get from London Airport to the West End than it does to go round the world.

● Printed on the cover of a United Arab Airlines brochure superimposed on a picture of the Pyramids: "UAA For Freight—specialists in moving difficult packages for 5,000 years."

● "*No other trans-Atlantic airline can offer cargo rates lower than these!*" shrills a member of IATA.

One thing about IATA fare-fixing: it certainly produces ingenious advertising.

● At London Heathrow last week one of my reporters interviewed Sir Charles Boost, prince of British air power and fount of all prestige. Sir Charles, affectionately known throughout the world as Boostie, had just flown back from Moscow, where he had seen the Soviet air show, and he was in a rapturous mood. Had he been impressed?

"Impressed, old boy?" he replied, as he climbed out of his S.E.5 executive wearing his famous Gosport flying suit. "I should say so. It was a wonderful show, wonderful."

What was his most lasting impression? "Oh, the noise—absolutely super noise, old boy. It was nothing but WHOOSH BANG WHOOSH for a whole hour." Sir Charles adjusted his goggles, stretched out his arms and roared round and round the tarmac, knocking over two BBC television cameras and a BEA Viscount.

Did he think the Russians had a technical military lead over the West? "No doubt about that at all, laddie. Everything they showed was years ahead of us, *whoosh!*"

And ahead of the Americans? "The Yankees aren't even in the race, old boy."

Could he be more precise? What aircraft had the Russians actually got that proved they were more advanced than the West? Had he been given performance details? Had he been able to take photographs? Had he been able to go to a bookstall and buy Russian aviation magazines like *Flight* and *Aviation Week* giving such details? What evidence had he got for going into such raptures over new Russian aircraft just because they were on show for the first time?

"I consider your questions to be frivolous and impertinent," snapped Sir Charles. "Who's giving the interview, you or me?"

This is part of the equipment of the Navy's first Wessex anti-submarine helicopter squadron, No 815. It explains the term UC (W) (Aircrew), which stands for under-water weapon control rating. The rating is lowered from the helicopter with the harp into the water, and when completely submerged plays a selection of Irish airs. All submarines in the vicinity are immediately lured to their doom by this seductive music; the rating and the harp are then raised, squeezed out and stored for future use. This is why the Wessex is such a big helicopter: you just can't find the cupboard space in a small one

Another in my Life Goes On series: A Yak-23 mounted at Warsaw Goclaw airfield, the centre for sporting, agricultural and ambulance flying. Though this jet fighter was obsolete years ago, I can't remember having seen a good close-up picture of it before. I hope we don't have to wait so long before we see close-ups of the newer-generation jets displayed at Moscow the other day

● Airline maintenance manager, quoted by an aircraft manufacturer:

This verse
Is terse;
No spares?
No fares.

● Evening newspaper placard in London on the day of Major Gagarin's visit: GAGARIN'S GREAT DAY.

ROGER BACON

Correspondence

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns. Names and addresses of writers, not for publication in detail, must in all cases accompany letters.

"The Most Economic Jet"

I READ with interest the article concerning Atlantic route fare rates (which appeared in *Flight* for June 22, page 877). The Boeing 707/DC-8 types of aircraft are acknowledged as being most suitable for routes of high traffic density. The Atlantic route, while having a very high traffic density in passenger numbers, is not dense when consideration is given to the number of carriers who share the traffic; load factors in the forties and low fifties appear to be the rule. From BOAC's costs given in *Flight* for May 20 (page 677), and taking the capacity payload of the 707-420 as 59,400lb, it is possible to calculate that a load of about 67 economy-class passengers is necessary to break-even on a Boeing 707 on the Atlantic route. As average load factor on the route fell by 7 per cent in 1960 and is even lower this year, a load of 67 passengers per flight is a marginal expectation.

It is apparent that what is required on the Atlantic is an aircraft in which a load of 67 economy-class passengers shows a reasonable profit. Such an aircraft is flying, namely the Comet 4. However, as is well known, the Comet 4 has insufficient tankage to allow regular non-stop flights in the westerly direction. It would seem that the problem can be overcome very shortly by re-engining the Comet with Speys. The thrust of the Spey is in the same bracket as the Avon, it is apparently 1 per cent more economic in the cruising regime and also it weighs 1,108lb less per engine. With these advantages a Spey-engined Comet 4 should have a still-air range of around 5,000 st miles, which should be sufficient for fairly regular non-stop Atlantic service.

It is interesting to work out how much profit the re-engined Comet 4 would make per annum with 67 economy-class passengers per flight and two return flights a day.

Total cost Comet 4 (Avon) per c.t.m.			= 22.4d
Capacity payload (81 economy layout), say 10 tons			
Cost per aircraft mile (22.4 × 10)			= 224d
Cost per round trip	=	$\frac{224d \times 7{,}000 \text{ st mi}}{240d}$	= £6,533
Revenue	=	67 × £163	= £10,921
Profit per round trip	=	£10,921	
		−6,533	
		£4,388	
Profit per annum	=	£3,203,240	(£4,388 × 2 × 365)

The Comet would break-even with only 40 passengers. It is obviously impractical for the airlines to forgo their tremendous investment in big jets, but, BOAC at least, by re-engining some Comets, could use the most economic jet for any traffic offering, at will.

Birmingham 22a — G. L. WILLIAMS

Ron Flockhart's Mustang

WITH reference to your three most recent issues—March 10, 16 and 23—available in Melbourne, I would like to make the following observations.

The Mustang flown to Athens by R. Flockhart was purchased from the RAAF by J. L. Whiteman on January 30, 1953, with a view to entering it in the forthcoming London-Christchurch Air Race. As A68-5, the fifth of a batch of 80 built from imported components, it spent most of its time in storage and as a consequence had only 35 airframe hours when demobbed.

As a prelude to the Air Race it was used to create a new trans-Tasman Sea record from Sydney to Auckland of 3hr 31.5min. Discouraged by such a slow time and by the Canberra entries he withdrew after attempting to obtain the prototype Avon-Sabre (A94-101) or a USAF Thunderjet.

The aircraft as VH-BVM was sold to A. J. Glass in mid-1954 and initially was frequently flown but in recent years has had little usage. In August 1959 it was used for target-towing experiments and flown by another Mustang owner, A. Oates. Department of Civil Aviation requirements will not allow ownership of former combat aircraft to be transferred, so the sale to UDT was probably most welcome.

Your reference to a trans-Timor record is not known, particularly as the furthermost point it had been flown to was Brisbane. Could Timor really be Tasman?

On page 380 of the March 23 issue Mr Masefield states "the Beagles are coming." Well, they had better be pretty quick, otherwise the market will be satisfied, as attached pages from this Society's monthly journal [not reproduced here.—Ed] will show. In the first case of 27 new additions, 16 are Cessna products while in the second the figures are 36 and 27 respectively. When the Cessna series are coupled with the progressive sales organization headed by Rex Aviation, agents of other aircraft find it hard to gain a foothold in the Australian market.

East Bentleigh SE15, Victoria — TREVOR W. BOUGHTON
Honorary Secretary, Aviation Historical Society of Australia

Flight-deck Manpower

I WAS very interested to read Mr D. R. D. Potts' views on flight-deck manpower (*Flight*, June 29), and as an airline co-pilot would like to add a further viewpoint.

As your correspondent pointed out, it takes (or should we now say, took) several years to become a licensed flight engineer. We can therefore deduce that whoever reached this elevated position was not only competent but also extremely interested in his job. The result: someone who could be relied on to look after the technical aspect of the aircraft's flight.

Now let us consider the co-pilot of today, for he is the person who appears to be replacing the flight engineer. He probably had between two and five years' Service flying, and during that time became aware of the fact that he was sufficiently interested in flying aeroplanes to make a career out of it. So on leaving the Service he spent a considerable amount of time and money on getting the necessary licences in order to obtain employment as a pilot and eventually become a captain.

The result now is someone who has not had quite as much experience in aviation but nonetheless is extremely interested in the career he has chosen—that of flying aeroplanes from A to B.

Having had a quick look at the two people concerned, we must consider who is the better person to sit at the engineer's panel. I would say that the one who is basically interested in the mechanical aspect of the aircraft, rather than someone who is more interested in, say, the timing of a holding pattern.

Nantwich, Cheshire — D. L. BISHOP

No Window, No Culture?

I GREW up in the railroad era. I became accustomed to having a window beside my seat so I could look out. With advancing age I became an occasional transatlantic air traveller (economy). Alas, it was no longer easy to see out of the window. Windows there were in profusion, but in no particular relation to the seats. I would crane my neck forward or back, as the situation required, and watch Mother Earth recede. Then I would relax, cooled by the little adjustable blast of air, turn on my reading light and pursue culture.

On my last two flights (BOAC Britannia) even culture was impossible. Perfect uniformity has been achieved. In these aeroplanes neither the windows nor the ventilator/reading light units had the same pitch as the seats. My reading light (or did it belong to the man behind me?) made a cosy warm patch on the top of my head.

Cambridge — C. W. MCCUTCHEN

All Done by Doubles

FOR Pete's sake let us not start another of these plane-spotter nightmare correspondences as exemplified by Mr Williamson's letter in the June 29 issue.

We know that stars mouth but do not sing. We know that it is not the hero who goes base over apex downstairs. It's all done by doubles.

Why then worry about a machine taking off in one guise, flying in another and landing in another?

"The story was good; the acting fairly good." Very well, then. If Mr Williamson wants to see aeroplanes let him go to London Airport—not to the cinema, where he will probably hear a biblical character referred to as a square and think nothing of it.

London W1 — F. H. SMITH

FORTHCOMING EVENTS

July	22	RN Air Station Lossiemouth: At Home.
July	22-23	Basse-Normandie Aero Club: 13th International Rally, Flers.
July	25-26	Portuguese-Spanish Rally.
July	26	Kronfield Club: "Gliding in Ghana," by G. A. Burgess.
July	27-29	International Business and Touring Aircraft Competition, Kidlington.
July	30-Aug 7	Derbyshire and Lancashire Gliding Club: Northern Gliding Contest.
Aug	1-13	Italian Gliding Championships.
Aug	27	Forli Rally.
Aug	27-Sept 3	Swedish Parachute Club: International Contest, Uppsala.
Aug	29-Sept 2	International Light-aircraft Exhibition, Luton Airport.
Sept	3	Wolverhampton Aero Club: At Home.
Sept	**4-10**	**SBAC Exhibition and Flying Display, Farnborough.**
Sept	6-10	FAI: European Air Tour.
Sept	8-10	Popular Flying Association: Rally, Cranfield.
Sept	11-15	Royal College of Advanced Technology, Salford: Course on Noise Measurement.

SERVICE AVIATION

Air Force, Naval and Army Flying News

Farewell flight by Javelin FAW.2s of No 46 Sqn, seen heading towards the Severn estuary after passing over the Gloster Aircraft works at Brockworth and Moreton Valence. Recently disbanded, No 46 became the first Javelin FAW.1 squadron in 1956

Commemorating Trenchard

A MEMORIAL statue of Viscount Trenchard was being unveiled yesterday (July 19) on the Victoria Embankment in front of the new Air Ministry building by the Prime Minister. The occasion was being marked by a parading of the Queen's Colour for the Royal Air Force in the United Kingdom; a fly-past from north to south by 16 Hunters of No 92 Sqn and wreath-laying by Air Chief Marshal Sir George H. Mills, Air ADC to the Queen, by the Prime Minister, Air Minister and Chief of the Air Staff. Viscount Trenchard was the first Chief of the Air Staff, in 1918; he died in 1956 at the age of 83. The architect of the memorial is Sir Albert Richardson.

Promoted Rear Admiral

TWO former captains of aircraft carriers, Capt H. R. Law, OBE, DSC, and Capt P. D. Gick, OBE, DSC, were promoted rear admiral from July 7. Rear Admiral Law commanded HMS *Centaur* on her commissioning in 1958: he is at present Captain, Britannia Royal Naval College, Dartmouth. Rear Admiral Gick took command of HMS *Bulwark* in January 1957 and was responsible for the carrier's prompt action in helping to salvage the tankers *Melika* and *Fernand Gilabert* in the Persian Gulf in 1958. During the war, he took part in the attack on *Bismarck* by aircraft of 825 Sqn from HMS *Victorious*; and he commanded 815 RN Air Sqn in the Western Desert from December 1941 to September 1942. He was CO of RNAS Lossiemouth before commanding *Bulwark*.

Hack Trophy Winners

SOUTHAMPTON UAS won the Hack Trophy—for the second time in three years—at Little Rissington on July 1. They scored 78 points, Leeds coming a close second with 76. Liverpool got 71.6 and Aberdeen 55.8. The trophy was presented to Southampton's commanding officer, Sqn Ldr A. A. Pearce, by the acting AOC-in-C Flying Training Command, AVM H. A. V. Hogan.

Air Cdre G. C. Hartnell, who commands RAAF Butterworth in Malaya, being congratulated by the CO of No 110 Sqn, Sqn Ldr C. Simons (left), after his first solo in a Sycamore. He received training from the squadron training officer, Flt Lt Bill Stevens (right)

Lt G. Bruce (centre) and PO O'Rourke of the Royal Navy taking delivery of a Canberra U.10 at Belfast recently from the Short Bros flight liaison engineer, Mr R. Lloyd, before taking off for Hal Far, Malta. The U.10s are used as high-speed targets for missile firing

Parachute School's 21st

AT Abingdon last Friday No 1 School of Parachute Training celebrated 21 years' existence. It was formed as the Central Landing Establishment at Ringway, Manchester, in 1940, and airborne forces were trained there for the great assaults of the Second World War—Sicily, Normandy, Arnhem and the Rhine crossing. At the end of the war, the School moved to Upper Heyford, then to Abingdon in 1950. In its 21 years over 120,000 parachutists have been trained and more than 750,000 descents made from some 18 types of aircraft.

The School is today commanded by Wg Cdr B. F. Stannard, AFC; it has 30 officer and 107 warrant officer and NCO instructors, all members of the RAF Physical Fitness Branch. Hastings and Beverley aircraft are chiefly used for instruction; towards the end of this year the AW.660 Argosy will be introduced. Training at the School was described in an article in *Flight* for May 6 last year.

IN BRIEF

The RCAF team won the Guynemer Trophy, awarded for the NATO air-firing competition, for the fourth consecutive year at Leeuwarden air base in the Netherlands on July 7.

AVM E. W. S. Jacklin, Chief of Staff of the Royal Rhodesian Air Force, retires on August 1 and is being succeeded by Air Cdre A. M. Bentley.

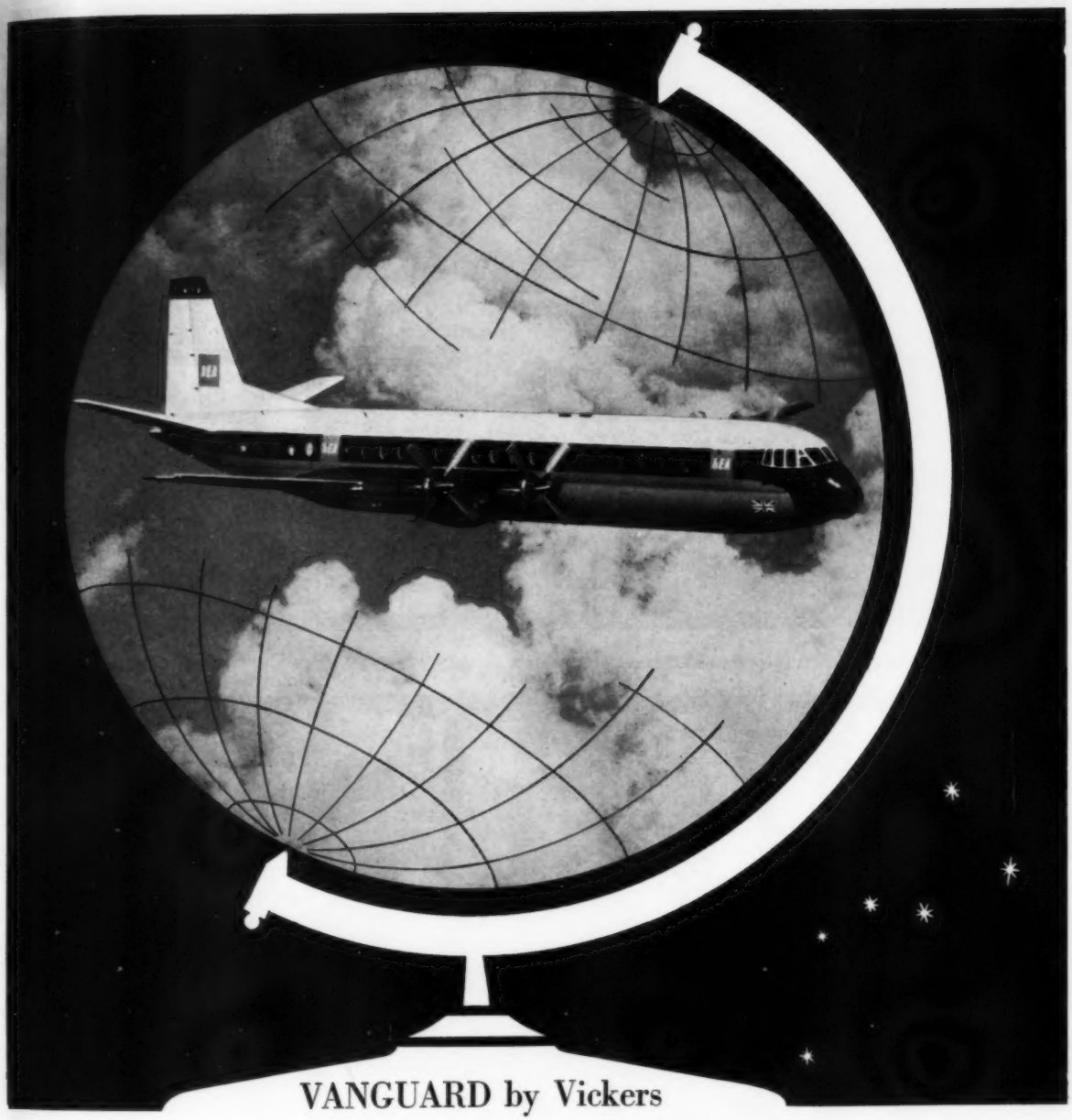
Gp Capt V. C. Otter, CBE, a former aircraft apprentice, has recently become STSO at Flying Training Command with the acting rank of air commodore.

Five squadrons from RAF Germany and one Royal Netherlands Air Force squadron are competing for the Sassoon Trophy—for photographic reconnaissance—on July 25.

Six officers who recently graduated at No 4 Flying Training School, Valley, set off after the wings parade on a 4,000 mile return journey to Greece in a hired bus as an initiative test. Led by Fg Off M. K. Field, they are to cover the route taken by Ulysses on his return from the Trojan War.

Fg Off Ian Strachan, a Valiant co-pilot at Marham and a member of the RAF GSA, recently became one of only three pilots in the Association to gain two Diamond "Cs." He took off from Lasham and flew for six and a half hours to Horsham St Faith via Edgehill in Warwickshire, under conditions which for half the distance were unfavourable with complete cloud cover.

Commissioning of the Royal Navy's first Wessex squadron, No 815, at Culdrose recently (this page, last week): Capt C. L. M. Webb, captain of HMS "Sea Hawk," addressing members of the squadron, whose insignia is a harp, commemorating the unit's sojourn at RNAS Eglinton in Northern Ireland



VANGUARD by Vickers

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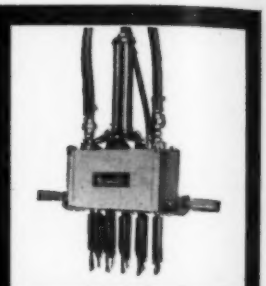
CHOUF!



A Desoutter multi-studrunner plants 9 studs into an Austin cylinder block.

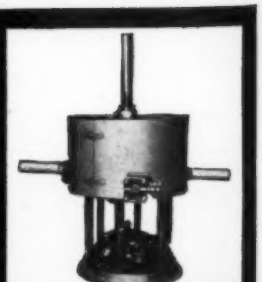
CHOUF!

A Desoutter multi-nutrunner fixes 25 nuts on a Ford diesel cylinder head.

CHOUF!

A Triumph Herald sump is put on by a Desoutter 16-spindle multi-nutrunner.

CHOUF!



A Desoutter multi-nutrunner assembles a Vauxhall clutch plate, or tightens the wheel nuts on a Rootes Group car. And so it goes on: the Desoutter CHOUF speeds mass-production, makes sweet music in industrialists' ears. And no wonder—everyone has a taste for that sort of music—and nearly everyone has something to play it on! CHOUF! (on a carburettor)... CHOUF! (or a light fitting)... CHOUF! (or a washing machine)... CHOUF! (or anything else that needs assembling).

DESOUTTER MULTI-NUTRUNNERS · SCREWDRIVERS AND STUDRUNNERS

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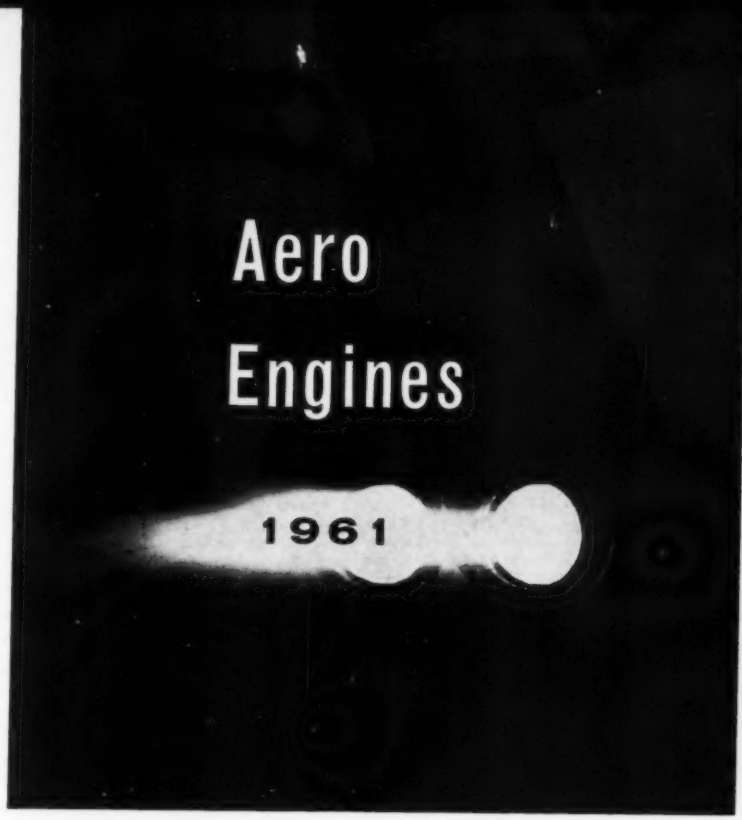


BY THE TECHNICAL EDITOR

IT is 15 months since our last review of the world's aero engines was published. In that time practically all the trends noted in former years have been maintained and intensified, and among these it is possible to single out a few for special mention. Starting at the bottom end of the speed scale, the piston engine is by no means dead yet; but, in the Western world, the only examples likely to remain in real volume production more than a year are the horizontally-opposed engines of up to about 400 h.p. And even in the fields of private-owner aircraft and light helicopters the small turbine is already forcing these engines to fight desperately for each new application.

It is worth considering the fact that these advanced, direct-injection flat-four and flat-six engines have behind them a half-century of steady evolution and refinement, and are priced for large production quantities against very modest development expenditure. The small turbine, on the other hand, has only really come into its own since M Szydlowski began to steer the Société Turboméca wholeheartedly in its direction in 1949; and until very recently no small turbine aero engine had received any substantial government finance. The small-aircraft field is one in which price, both capital cost and direct operating cost, matters a very great deal; and the five or six firms who have really tackled the task of producing turbines to suit it have had an uphill fight.

One of the most competitive series of small turbines appears to be the CT58 turboshaft, CF700 turbofan and CJ610 turbojet by General Electric; and these are singled out to emphasize that they are not completely priced out of the market, even though they are products from one of the largest companies in the world (the actual prices are given in the appropriate part of this review). Overheads are understood by few, and disliked by all; but they are very real barriers to the production of truly advanced cheap turbines for small aircraft. In the past there has been a danger of the customer being offered the choice between an uncertificated and uneconomic "back-yard" engine at a reasonable price, and a certificated and highly efficient unit at a price greater than the figure at which he hoped to market his complete aircraft.

The fighting services have found money increasingly hard to come by; even in the United States, several powerplant decisions of far-reaching importance have been taken since we last examined the picture, largely because so much hard cash has been poured into space flight and the "bottomless pits" of ICBM silos. It is a truism to assert that, if a firm employs 90,000 people, as does The Boeing Company (last year, be it noted, "the Boeing *Airplane* Company), it has to run terribly hard to stay in the same place. Ten years ago the future of US airframe builders never looked rosier, whereas today the visitor to both West and East Coasts can detect deep-seated changes which are completely transforming the outward appearance of these companies. The trend has already begun, in a very marked degree. Martin, who once were leaders in the frame-making business, have "sloughed off" (their own words) their emotional attachment to it; Lockheed's relatively successful aircraft interests have been not merely subordinated to their other divisions but literally swamped by the 55,000 on the payroll of their Missile and Space Division; even Douglas and Convair may not be far from seeing their last aeroplane.

This review of airframe firms is inserted in order that the reader may better understand the problems of the traditional engine-makers. Pratt & Whitney appear to be flourishing, but their development costs are soaring while their production runs per model dwindle from 10,000 to 1,000, and from 1,000 to 500. Allison and General Electric are fighting valiantly to retain their share of the remainder of the aircraft-propulsion market; but both have long since moved into other fields and taken comfort in the thought that they are parts of much larger concerns with immensely broad industrial bases. Increasingly, the requirements of the space programmes and military services have little in common with the needs of people who buy aeroplanes, and while the former may help keep a company in business it is now rare for a commercial aero-engine programme to be able to ride on the back of a military one.

The outstanding exception to this picture of "Fings Ain't Wot They Used T'be" is the supersonic transport. Many wish the SST could quietly be forgotten for a dozen years, while others are fascinated by it as a bird is by a snake. It is impossible to weigh the importance of such human emotions as national pride or company pride, the desire to beat a massive technological challenge "because it's there," or simply some blurred belief in "progress"; but the SST will never be put aside for a moment, and finding the optimum powerplant for it is practically the only really formidable development task that the world's builders of aeroplane engines have to face. Previously, the development of a nuclear propulsion system for aircraft was a comparable challenge, but President Kennedy—undoubtedly rightly—has killed this weighty bird stone dead, the programme finally grinding to a halt three weeks ago.

But there will be other huge challenges. After all, there are not many who would care to define exactly what is meant by the term "aircraft," and the author has often had to take quite arbitrary decisions in allowing the ensuing pages to include the engine of the X-15 and not that of the pilotless Blue Steel, or the engine of the drone ASW helicopters and not that of the Redstone which gave so great a push in the back to Cdr Shepard. And even if traditional markets are giving place to new ones, there is no lack of competition in fighting to hang ever-better engines on the diminishing number of ever-better aeroplanes. It is a field in which the United Kingdom has excelled. For many months our exports of aero engines have been running at a higher level of net worth than our exports of aircraft; they brought us £73,700,000 in the calendar year 1960, and £356,000,000 since 1945.

AERO ENGINES 1961 . . .

Great Britain

ALVIS *Alvis Ltd, Coventry.* Although the earlier types of Leonides nine-cylinder radial piston engine are still in production at ratings of the order of 560 h.p., the most important unit is the Leonides 531, in which the piston stroke is increased to 4.8in. The new marks of Leonides also have longer pistons and are generally strengthened to permit them to operate at their increased level of power (Table 6). Installed in the Twin Pioneer Series 3 these engines confer an increment of additional performance which is especially valuable in operations from hot or high airfields. A considerable number of RAF Twin Pioneers are at present being fitted with the new engines.

ARDEM *Rollason Aircraft & Engines Ltd, Croydon Airport, Surrey.* The Ardem 4C02 flat-four is being produced at Croydon by arrangement with M Roger Druine, the designer, and the Popular Flying Association. The basic engine has twin Lucas magnetos and an impulse starter, in place of the original dual magneto of French design. Rollason have also fitted aluminium cylinders of larger bore, raising the output from 30.7 to 40 h.p. and reducing the weight of the engine by 12lb. Another modification is the fitting of a Solex side-entry carburettor and a hand-starting device in the cockpit. The company have delivered 26 engines, and the 17 Turbulent aircraft in their own charge have now flown over 2,500hr.

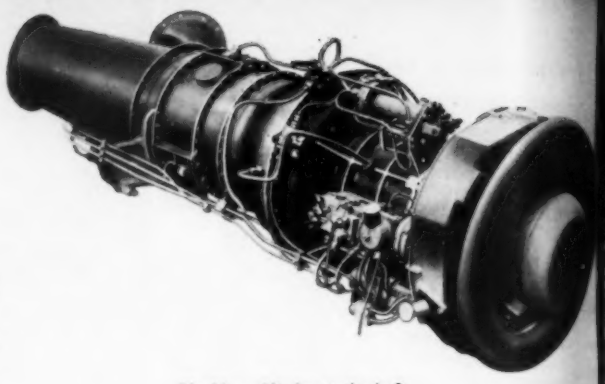
BLACKBURN *Blackburn Engines Ltd, Brough, Yorkshire.* This company was formed in April 1959 to co-ordinate the aero-engine activities of the Blackburn Group, which in turn merged with Hawker Siddeley last year. By far the most important aircraft-propulsion engine is the Nimbus, but limited service-support and overhaul work is in hand for the Palas 600 turbojet, Palouste 500 compressor and Turmo 603 free-turbine engine in service with the Royal Navy in the Westland P.531 Mk 0 helicopter. In addition, large numbers of Artouste and Palouste are employed in non-propulsive applications, particularly for starting aircraft engines and driving airborne auxiliary powerplants. The company's newest engine is the Cumulus, and, although performance data are given in Table 5, it is not yet a certainty that the company will decide to produce an aircraft-propulsion version.

ENGINE DATA ARE TABULATED AT END OF THIS REVIEW

Nimbus Originally known by the type-number of A.129, this engine is basically a Turboméca-derived unit, but with its performance enhanced by the addition of a two-stage transonic axial compressor upstream of the centrifugal stage. The free-turbine output is at the rear, and in the Westland Scout helicopter powers the rotor through primary and secondary reduction gearboxes leading forwards beneath the engine. After early testing as a turbojet in July 1958, the Nimbus ran on the dynamometer in August of that year at 840 s.h.p. Most of the running has been at the level of 968 s.h.p., but Blackburn now speak of the Nimbus as "in the 1,100 h.p. class," and emphasize its robust and economical design. Quantity production is in hand for the Scout, and a slightly different version will be installed in the SRN.2 Hovercraft.

BRISTOL SIDDELEY *Bristol Siddeley Engines Ltd, Mercury House, Knightsbridge, London SW7.* Having demonstrated that two rival companies can effect a true integration—which essentially meant overcoming any feelings of "us" and "them," by creating a new corporate image able to command the loyalties of all 25,000 employees—Bristol Siddeley have also overcome virtually all the "agonizing reappraisals" that were needed to put their house in order. Had they not merged, Bristol Aero-Engines and Armstrong Siddeley Motors would undoubtedly today be but shadows of their former selves. As BS, they still have nothing like the aviation business of Rolls-Royce or Pratt & Whitney; but what they have is firm, what they may reasonable expect to win is much greater and they also have the advantage of considerable non-aero business allied to sound management. It was originally dictated that Patchway (Bristol) would be the Aero Division, while Ansty (Coventry) would be the Power Division. In the event, aero engines have by no means disappeared from Coventry, although the main effort of design and development is now at Bristol. Remaining at Ansty and other Coventry establishments are portions of previous ASM programmes, and all work on rocket engines. The latter are not for aircraft, but include such renowned powerplants as Gamma, for Black Knight, and Stentor, for Blue Steel. The Power Division make many other products, in particular the excellent Maybach MD-650 and other high-speed diesel engines for rail traction.

BS.53 Pegasus Genesis of this unique powerplant was outlined in *Flight* for August 12, 1960. After passing through various evolutionary stages, it was finally turned into metal in 1959 as the most neat and efficient way of making a relatively conventional gas turbine provide



Blackburn Nimbus turboshaft

both lift and thrust without itself pivoting bodily. Essentially the Pegasus is a high-by-pass-ratio turbofan with exit nozzles on each side for the fan air and further lateral nozzles for the hot jet at the rear. All four nozzles are provided with efficient cascade vanes, and rotate in unison to turn the whole efflux forwards, downwards or to the rear, to impart braking, lift or thrust to the aircraft.

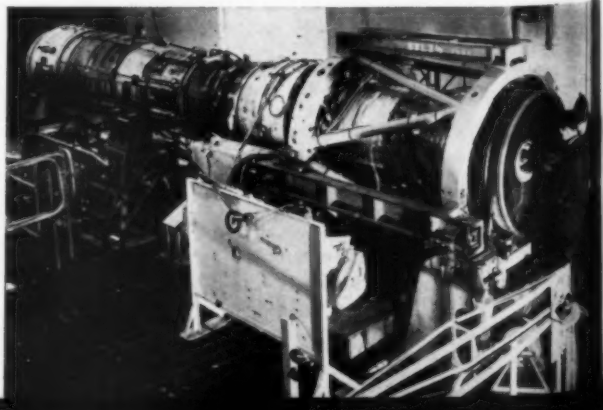
From an early stage the project was in receipt of funding from the Mutual Weapons Development Program, since it promised to meet a common NATO requirement for a V/STOL combat powerplant. The first engine ran on the bench in 1959 as a complete unit with nozzles and air bleeds for aircraft stabilization, and running in this ground rig sorted out most of the major unknowns at an early stage. First application of the Pegasus is the Hawker P.1127 tactical strike fighter, which was designed around the engine partly to achieve minimum weight—always a prime requirement in jet-lift aircraft—and partly to minimize undesirable pitch, yaw or roll moments, particularly during nozzle rotation. The aircraft completed hovering trials last year, flew as an aeroplane in March and is now approaching the stage when complete transitions can be effected. It is obvious that the P.1127 has always been short of all the thrust it would like, and will eventually get; but the experience already gained is unparalleled in any other country.

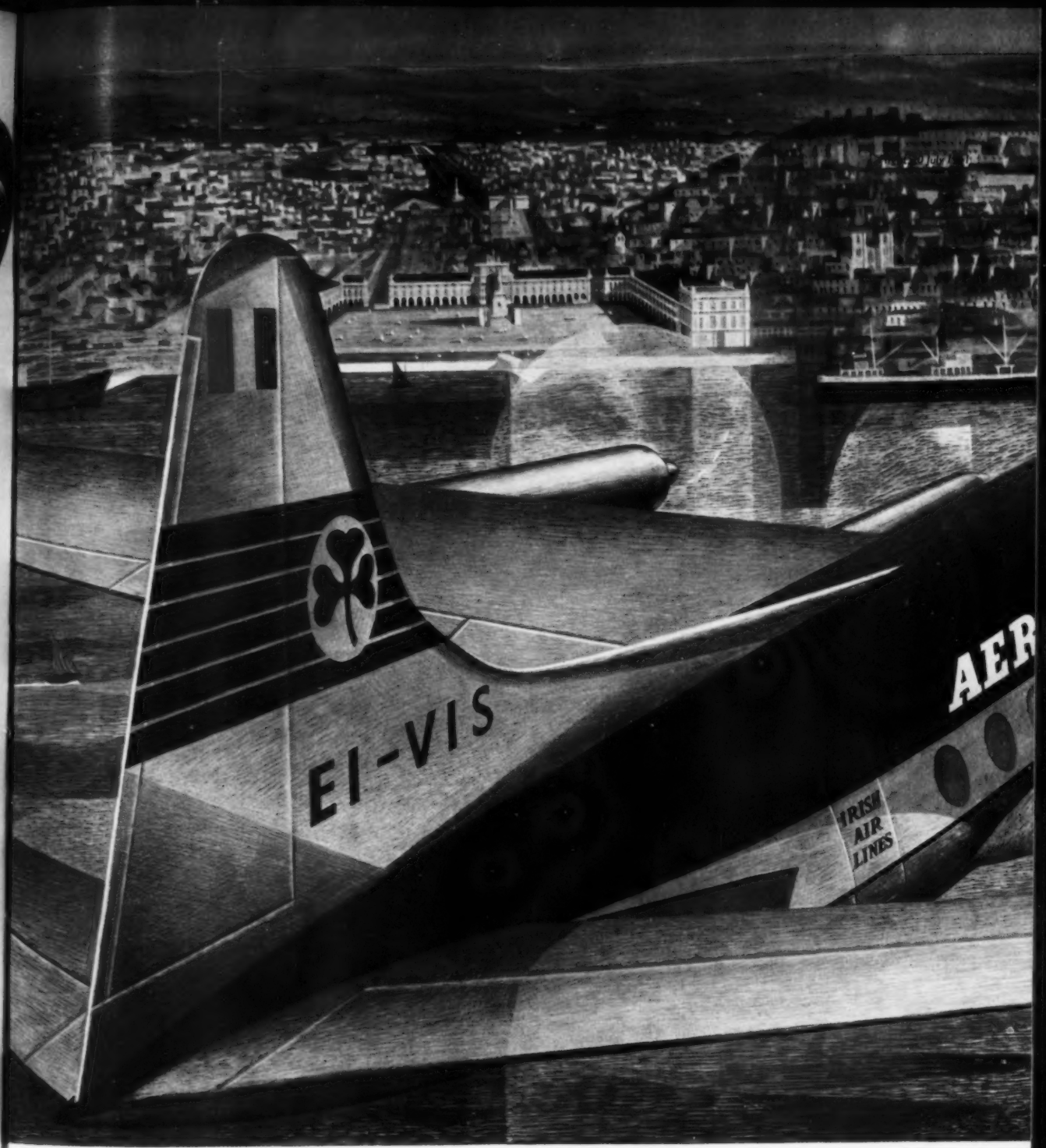
The fundamental drawback to a single lift/thrust engine is that the thrust needed for lift makes the unit too large in other regimes, and the throttling in cruising flight may increase specific consumption. Nevertheless, this is a drastic oversimplification, and—in particular for shorter ranges—the Pegasus concept is in many types of application demonstrably superior to all rivals. Development of the engine is being further accelerated by the increased British and MWDP funding announced in April, and appreciably greater thrusts will be forthcoming. Duct-burning of additional fuel in the fan air would at once give a very handsome increment, and the increased s.f.c. in the lift regime would be counteracted by the reduced s.f.c. in the cruise with a bigger aeroplane. Republic/Fokker have announced their interest in Pegasus for a supersonic VTOL fighter for NATO and other constructors have Pegasus-engined projects ranging from supersonic fighters to four-engined transports.

BS.75 As yet unnamed, this turbofan is the BS entry in the stakes for the optimum engine in the medium-sized, high-subsonic class. Although it has yet to run it is largely a synthesis of very well proven components, including a fan which owes much to the Olympus, a high-pressure compressor aerodynamically similar to the compressor of the Orpheus, a combustion chamber which likewise betrays traces of Orpheus influence and two-stage compressor and fan turbines which have much in common with those of the Proteus. It should not be inferred from this, however, that the BS.75 is a mere "lash-up" of bits of old engines. Its design has been most carefully considered over a period of years, as was related in our issue of August 12 last year, and while it is logical to draw the maximum possible benefit from the service experience of existing engines, the design of the BS.75 is completely uninhibited.

By-pass ratio has been set at a value higher than that for any other British engine, largely owing to the fact that the BS.75 is aimed particularly at aircraft with modest cruising speed but likely to operate where noise will be all-important. The specification (Table 2) is challenging.

Bristol Siddeley Olympus BOl.7R reheat turbojet on test stand





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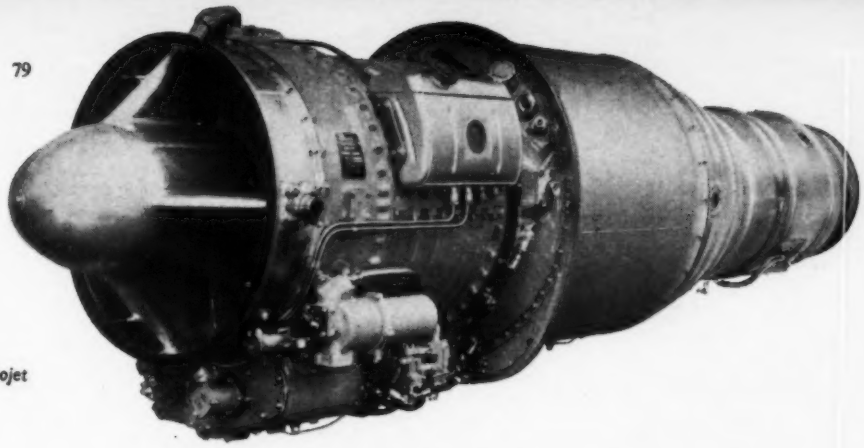


Bristol Siddeley Orpheus 803 turbojet

AERO ENGINES 1961 . .

and if the development engines due to run during the coming winter confirm these figures the commercial success of the BS.75 should be assured. It is sized to fill a gap which has not yet been attended to by any other manufacturer, and although its most obvious immediate application, the British Aircraft Corporation 107, is temporarily shelved, the powerplant "has been chosen for at least two other projects, not including the Avro 771."

BS projects Although it is never likely to be built, the BS.58 has been included in the table of turbofans largely in order to give a clue to the characteristics of the BS.53 Pegasus, from which it is derived. The BS.72 commercial fan engine has figured in some published papers, but is again not a likely runner, and the most important gleam in the eye of the BS board is a unit said to be designated BS.100. According to unofficial reports, this is a lift/thrust engine rated at something like 30,000lb at sea level, a figure which would enable aircraft designers to produce a really worthwhile V/STOL attack machine. Although obviously based on both Pegasus and Olympus, such an engine would probably require a wholly new front fan; and, in supersonic applications, fan burning.

Olympus First run in 1950 at its design rating of 9,140lb—then an ambitious figure—this superb two-shaft turbojet has been developed until it now has a dry thrust in excess of 20,000lb and a reheat rating of 33,000lb. The original version of the engine entered production in 1955 with a dry rating of 11,000lb, and this series terminated with the Olympus 104, the standard powerplant of the Vulcan B.1, with a dry rating of 13,500lb. Bomber Command have announced that these engines are "the RAF's most powerful, most efficient, and most reliable combat engine, with the highest overhaul life and lowest premature-removal rate." Engine handling has also been officially praised, "particularly at heights above 50,000ft."

Second-generation engines began with the BOl.6 Mk 200, in which airflow was increased and the number of compressor stages reduced without any penalty in overall pressure ratio. The standard powerplant of the Vulcan B.2 is the BOl.7 Mk 201, and the behaviour of the Vulcan 2 in operational service suggests that this much more powerful engine is in no way inferior to its predecessor. The BOl.21 clearly has a zero-stage, and has been designed "to allow the Vulcan to reach its ultimate design potentialities." In production form the 21 is the Olympus Mk 301, and it is at present flying in the engine manufacturer's own Vulcan test bed. A development of such an engine, fitted with Bristol Siddeley/Solar fully variable reheat, has a thrust of 33,000lb. Engines of this type are making good progress in the challenging search for the optimum powerplant installation for the British Aircraft Corporation TSR.2. It is appropriate to note that this experience should carry across directly to a supersonic transport.

Orpheus Simplicity and reliability were uppermost in the minds of the designers when this single-shaft turbojet was planned eight years ago. The first example flew at an initial rating of 3,825lb in the prototype Gnat in 1955, and the engine has now become virtually a world standard in this thrust-class. The most important versions are the Mk 701 for the Gnat fighters, Mk 803 for the Fiat G.91 family (and licence-produced in Italy and Germany for installation in these aircraft), the Mk 805 for the Japanese Fuji T1-A trainer and the Mk 100 for the Gnat T.1 of the RAF Flying Training Command. The Mk 100 is derated and provided with special equipment to ensure a long and trouble-free life under arduous training duties. The Hindustan HF-24, powered by two Orpheus 703s, flew for the first time last month. Earlier this year Japan placed a repeat order for engines for T1-A aircraft, and it was announced that a large additional batch of Orpheus is among the items to be supplied to Germany under the agreement between the British and German defence ministers last May.

Proteus Also widely employed in industrial and marine applications, this free-turbine engine has flown some 2,000,000hr in Britannias in all parts of the world. Overhaul life of the Proteus 705 should soon reach 2,800hr, several engines having been examined at this figure; the 750/760 series have lives between 1,350 and 2,000hr.

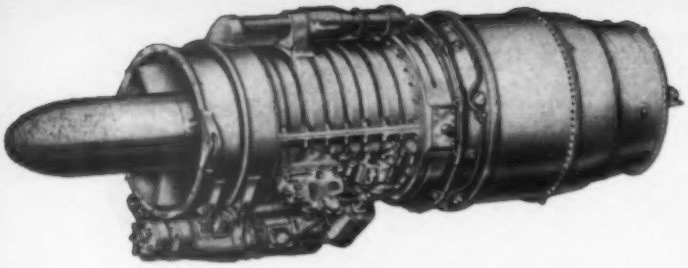
Viper Conceived as a 1,640lb short-life turbojet for missiles and drones, the Viper's principal applications today are the propulsion of trainers and executive aircraft, for which long and trouble-free life is a paramount requirement. The original first-generation aircraft engine was the Viper Mk 101, weighing 525lb, giving a dry thrust of 1,750lb and fitted to the Jet Provost T.3. Its performance and reliability in service has been exemplary, and has facilitated the progressive uprating of the engine, first to the 2,460lb level of the Viper 11 and now to the 3,000lb rating to be established by the new Viper 20. The Viper 11 is in production for the Jet Provost T.4, Macchi MB.326 and the Jindivik 3 family of targets. The new ASV.20 incorporates mechanical changes so that, in spite of its increased thrust, it remains a conservatively rated engine. Its first announced application is the de Havilland 125 Jet Dragon, and another Viper-powered executive aircraft is likely to be announced shortly.

DE HAVILLAND *The de Havilland Engine Co Ltd, Leavesden Aerodrome, Herts.* Now part of Hawker Siddeley Aviation, this large and versatile company is active in many power-conversion fields, including nuclear engineering. Production of piston engines is concentrated upon the Queen 70 Mk 3 rated at 400 h.p.; manufacture of the Major 140 and turbosupercharged Major 215 has ceased, but spares for these engines and for the large number of earlier Queens and Majors, together with the overhaul and repair of Goblin and Ghost turbojets, continues to bring in business on a very large scale. The Spectre 4 is in limited production for the RDS.15 take-off boost package for the Victor, a large number of Super Sprite take-off packs have been produced for Valiant service, and the RDS.33 Double Spectre powerplant has been delivered in quantity for the Blue Steel test vehicles.

Gnome The company have had a technical-interchange agreement with General Electric (USA) since 1951, and early in 1958 an agreement was signed for the production by the British company of the General Electric T58 turboshaft. The Gnome is in no sense a copy of the American engine, but is a natural anglicized descendant which has now branched out into a family of powerplants of major importance. The first British-built engine ran in June 1959, and helicopter versions are now in quantity production against orders placed by the Ministry of Aviation, and by major customers in Italy, Sweden, Ghana and elsewhere.

Distinguished by the prefix H, the helicopter engines have a rear drive from the free turbine, and differ from their American progenitor principally in having an entirely new control system developed jointly by de Havilland Propellers (now D. H. Aircraft) and Lucas, and by re-

Bristol Siddeley BS.53 Pegasus lift/thrust engine



Bristol Siddeley Viper 20 turbojet

AERO ENGINES 1961 . . .

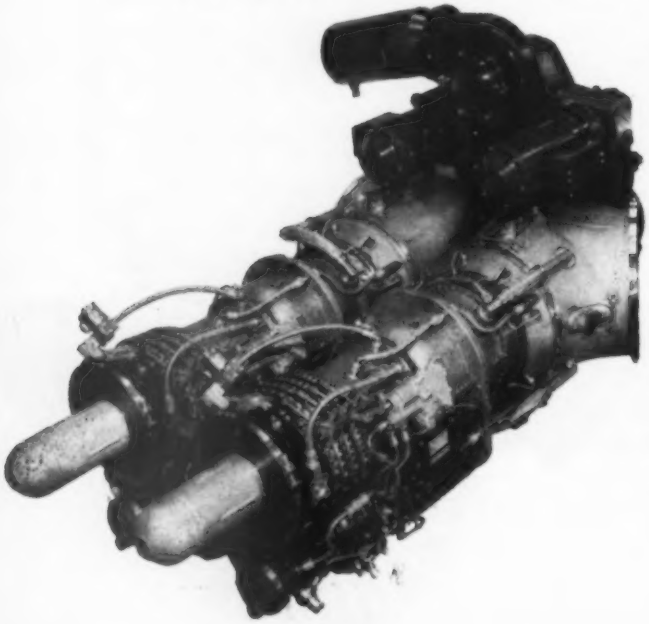
arranged British accessories. The Gnome H.1000 is in production for the Whirlwind HAR.10 and for the conversion of existing Whirlwinds in RAF service, and production deliveries have been in progress for some time. Deliveries have also been made for the Agusta 204, which made a most favourable impression at the recent Paris Salon. Uprating to the H.1200 and later H.1400 levels is already in hand, both figures representing the 1hr rating.

The application involving the greatest development effort has been the propulsion of the Wessex Mk 2, for which purpose two Gnome power sections are joined to a common gearbox to form the Coupled Gnome H.1200. The standard reduction gearbox can drive to front or rear in parallel with the engine axis, but for the inclined Wessex installation a completely new arrangement has led to a single gearbox which performs the functions of coupling, speed-reduction and the provision of drives for two 9kW generators, a hydraulic pump, oil-cooler fan, three tachometer generators and the pumps for the self-contained lubrication system. Freewheels are incorporated to allow the helicopter to fly with either power section out of action. Although the theoretical 5min rating of the powerplant is 2,500 s.h.p., the Wessex rotor is at present limited to 1,550 s.h.p. Should one Gnome fail, the engine control system automatically brings up the power of the remaining unit to meet the rotor demand within the limit of its 2½min contingency rating of 1,350 s.h.p. and 30min rating of 1,250 s.h.p.

In contrast to General Electric, D.H. Engines have produced a turboprop family, characterized by the prefix P. The first P.1000 ran in September 1960, and a Dakota is now being fitted with two of these engines for flight-test purposes. The P.1200 is likely to be the first production version, and should complete its certification, together with its specially designed de Havilland three-blade propeller, within a year. Overhaul life of the first production Gnome turboshaft and turboprop versions has initially been set at 400hr, but may rise to 1,000 by the end of next year. It is noteworthy that in the turboprop the gas-producer is readily detachable as a unit, and may thus have a life pattern differing from that of the output shaft and propeller drive.

Gyron Junior Originally a direct two-fifths scale of the Gyron turbojet, with seven-stage compressor, the Junior has found only one production application, although its outstanding thrust per unit weight and frontal area compare more than favourably with contemporary powerplants. The original PS.43 engine retained the seven-stage compressor, running on the bench in August 1955 and flying in a Canberra in May 1957. The production DGJ.2 Mk 101 has a zero-stage on the compressor and variable inlet guide vanes and first stators. Around the combustion chamber is a bleed manifold for handling the exceptional flow of air required for boundary-layer control purposes in the Blackburn Buccaneer S.1 aircraft. A large number of Mk 101 engines have been delivered for this aircraft, and service with the Royal Navy is imminent.

de Havilland Coupled Gnome H.1200 turboshaft installation



The more advanced DGJ.10R and DGJ.20 are designed for flight at Mach numbers greater than 2.5, and this powerplant is about to fly in the Bristol 188 all-steel research aircraft. Flight trials of identical units have been in progress using a Javelin as test bed, and ground-running of this aircraft at Hatfield forms the subject of the heading illustration on page 77. The afterburner gives 40 per cent static augmentation at 2,000°K, and has a fully variable convergent/divergent nozzle.

NAPIER *Napier Aero Engines Ltd, London W3.* The formation of this new company jointly by English Electric and Rolls-Royce was announced last month. It embraces all the aviation-propulsion activities of D. Napier & Son Ltd, who nevertheless continue their other aeronautical activities, particularly at Luton. The new company incorporates the London group of factories, chiefly at Acton, where all design and production of aero engines is now centred.

Eland The basic Eland 504 turboprop was the first turboprop in the world to complete all certification for ARB and FAA approval, and it is now in scheduled service with Allegheny and Quebecair. The company have recently published a design study note to substantiate all the weight and performance figures published in the Convair/Canadair 540 brochure, and service experience at an initial life of 800hr has been very satisfactory. Similar military engines are in RCAF service in CC-109 aircraft and well over 1,550hr has also been logged by the E.151 powerplant of the prototype Westland Rotodyne. Future development is aimed principally at clearing the E.248 turboprop at 3,470 s.h.p. (3,750 e.h.p.) for take-off and 3,165 s.h.p. (3,420 e.h.p.) continuously.

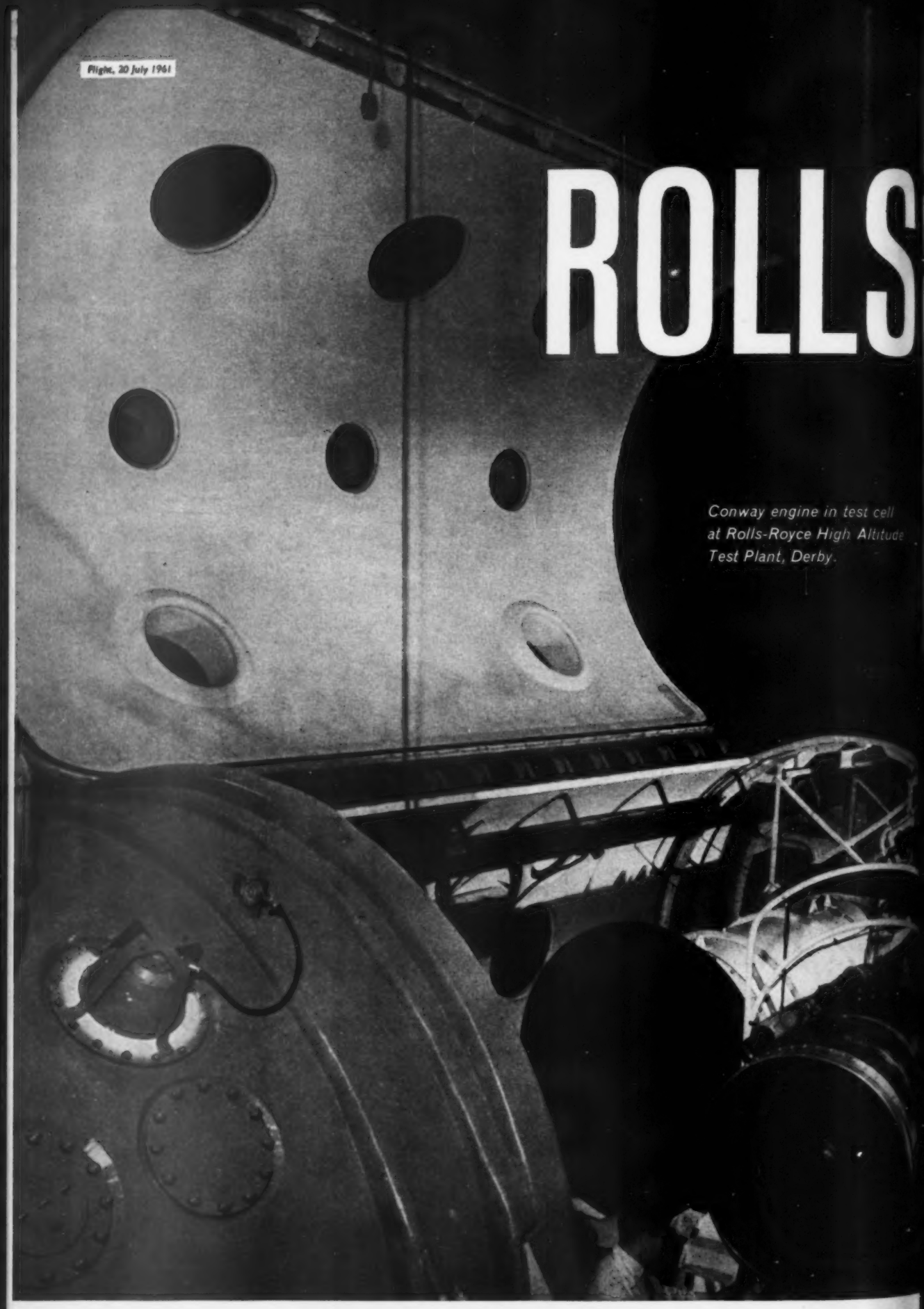
Gazelle This free-turbine, any-attitude helicopter powerplant is by far the most important Napier aero engine today. Design began in June 1954 and the first engine was run in December the following year. In May 1957 a Gazelle flew in a Wessex, and in July 1958 two engines powered the first Westland Belvedere. The former helicopter is powered by the Gazelle 161 (NGa.13), rated at 1,450 s.h.p., while the Belvedere has two Gazelle 101s (NGa.2 rating) of 1,465 s.h.p., with a special engine-out contingency rating of 1,650 s.h.p. Both units are fully cleared for service operation, and are at present engaged in special cold-starting tests with various types of starter.

By the end of this year it is estimated that about 40,000hr will have been logged, half of this being flight-time in the Belvedere and Wessex. Performance in both installations has been exemplary, and not only was flight in sandstorms found to be entirely practicable without damage, but no power was lost due to temperature conditions other than those due to direct accountability (a unique accomplishment for a helicopter engine). Future Wessex and Belvedere helicopters will have the installationally identical Series 2 versions of their present powerplants, rated at 1,330 s.h.p. continuously, 1,540-1,575 s.h.p. for intermediate contingency and with a special rating of 1,750 s.h.p. for the Belvedere. The next development, for an imminent mark of Wessex, will be the NGa.9, which although torque-limited will have intermediate and maximum contingency ratings of 1,750 and 2,000 s.h.p. The most advanced Gazelle at present under development is the NGa.20, with continuous, intermediate and maximum ratings of 2,210, 2,460 and 2,970 s.h.p. Work is also continuing on the commercial Gazelle 512 (with corresponding ratings of 1,275, 1.575 and 1,750 s.h.p.), which has a redesigned front end incorporating an axial intake and other features conforming to the installational requirements of transport helicopters.

ROLLS-ROYCE *Rolls-Royce Ltd, PO Box 31, Derby.* Occupying a unique position in the aero-engine field, this great company employs more than 49,000 people in the United Kingdom alone. Of this formidable total, more than 40,000 are members of the Aero Division, with headquarters in Derby and other major facilities at Hillington, East Kilbride and Blantyre (Glasgow area), Barnoldswick, Mountsorrel and (Flight Development Establishment) Hucknall. More than 10,000 of the staff are design and development engineers working purely on aeronautical problems. The company's substantial interest in large rocket engines stemming from their MoA contract to develop the RZ12 propulsion system for Blue Streak is not covered in this account, but new information is given on the work of the Light Aircraft Engine Department, which is part of the Motor Car Division at Crewe. Statistics worth noting are that in 1952 no less than 71 per cent of the sales of all Rolls-Royce divisions represented purchases made by the British Government, whereas in 1960 the proportion had dropped to 33 per cent. Yet the overall volume of business has in no way suffered, thanks to the company's enormous investment and effort aimed at producing the best commercial powerplants in the world. In 1960 the company exported a record total of £53m, and of this a very high percentage was accounted for by aero engines. New aero-engine business in 1960 was double that for 1959.

Windscreens by TRIPLEX

Flight, 20 July 1961



ROLLS

Conway engine in test cell at Rolls-Royce High Altitude Test Plant, Derby.

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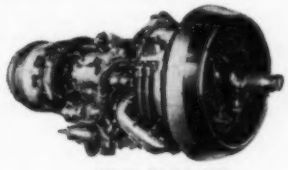
DART PROP-JET



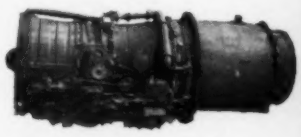
TYNE PROP-JET

ROLLS-ROYCE GAS TURBINES CHOSEN FOR

ARMSTRONG WHITWORTH ARGOSY · AVRO 748
BOEING 707-420 · BRITISH AIRCRAFT CORPORATION ONE-ELEVEN
CANADAIR FORTY-FOUR · DE HAVILLAND COMET
DE HAVILLAND TRIDENT · DOUGLAS DC-8
FOKKER & FAIRCHILD F.27 · GRUMMAN GULFSTREAM
HANDLEY PAGE DART HERALD · NAMC YS-11
SUD-AVIATION CARAVELLE · VICKERS VANGUARD
VICKERS VISCOUNT · VICKERS VC.10

AVON TURBO JET

CONWAY BY-PASS JET



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de Havilland Gyron Junior DGJ.10R reheat turbojet

AERO ENGINES 1961 . . .

Avon Development of the military Avon turbojets is continuing for future marks of Lightning and Draken. Most of the units in current production are of the RA.24R variety, with a high flame temperature and air-cooled turbine blades. These engines have a dry rating of 11,250lb, and a thrust with full reheat of 14,430lb. The later RB.146 is scheduled to go into production as the Avon 300 series, and the addition of a zero-stage on the compressor, matched by a slight increase in the diameter of the low-pressure turbine, results in dry and reheat ratings of 13,230 and 16,600lb respectively. The Avon Mk 67 of this family has performed superbly in a Mirage, in conjunction with a 36in fully variable ejector nozzle. Similar engines are going into production in Sweden (*q.v.*).

Commercial Avons all have the zero-stage on the compressor, and a three-stage turbine. First production engine was the Mk 524 of RA.29/1 rating, and these units have now flown some 750,000 of the million hours flown by Avons in airline service. Last week the engines in BOAC Comet 4s were cleared for 2,900hr between overhauls, and trials are in progress to 3,200hr (twice the overhaul time achieved by the next-best airline turbojet). For the Caravelle, Rolls-Royce have progressively increased the thrust of the commercial engine, initially to 11,400lb by improving the blade material and fitting a two-position nozzle. This RA.29/3 powers all Caravelles currently in service, except for the very latest aircraft. The latter are the Caravelle 6 and 6R, which have appreciably more powerful engines with a zero-zero stage on the compressor. The basic RA.29/6 is the Mk 531, rated at 12,200lb, which entered scheduled service with Sabena in February. The Avon 532R (R for "reverser") incorporates improved materials and cooling arrangements in the first turbine stage and is rated at 12,600lb. These engines entered scheduled service with United on July 14, at an initial FAA overhaul life of 1,200hr. These are the first non-American turbojets ever to go into service with an American operator.

Conway Development of the present family of Conway by-pass turbojets began in 1956, when Trans-Canada Air Lines chose such an engine for their DC-8 aircraft, while the MoS ordered a similar unit for the Victor B.2 bomber. The need to fit the engine into the wing of the Victor restricted overall diameter and caused the by-pass ratio to be fixed at the low value of 0.3. Production deliveries began in 1959, and in April 1960 scheduled service began with several operators using the RCo.12 engine in the DC-8-40 and Boeing 707-420. The latter aircraft has the Mk 508 engine installed in an all-British pod incorporating a Rolls-Royce reverser and silencer, while the Douglas installation consists of a Mk 509 Conway in a US nacelle installation similar to that employed in other DC-8s. Teething troubles, related in great detail in our issue of May 18 last, were at no point unduly severe and appear to have been overcome in a most encouraging manner. During the summer of 1960 the unscheduled-removal rate through Rolls-Royce responsibility suffered by the largest operator (BOAC) was running at around 0.6 per month per thousand hours flying. The comparable figure for March, April and May of this year averages out at 0.083 and all Conway operators are today very well pleased with the engine's behaviour. Total hours flown in scheduled service has now passed the 400,000 mark, some 70 per cent of which has been logged by the Boeings. Most operators have their engines on a 1,600hr life, with trials to 1,800hr, and 2,000hr is anticipated before the end of this year. The Rolls-Royce reverser has a separate life pattern, and is at present being inspected every 2,100hr.

The solid background of experience gained by such engines as the Dart and Avon has enabled Rolls-Royce to increase the power of the Conway substantially. Early last year bench-testing began on the RCo.15B, with a guaranteed minimum rating of 18,500lb, and in March of this year bench-testing started on the completely new RCo.42/1. This "1¼-generation" engine has an entirely new low-pressure line, consisting of a compressor of increased capacity and a rebladed turbine. This gives double the by-pass ratio of the earlier engines, coupled with a substantial increase in thrust, yet the critical hot parts remain similar to those of the RCo.15B. By the time the RCo.42/1 enters service these parts should have lives of the order of 6,000hr and be thoroughly well proven. The RCo.42/1 is now in production for the Vickers-Armstrongs VC10, and deliveries for certification testing are due to begin in September. Most of the 51 of the Vickers big jets now on order will be of the Super VC10 type, powered by the RCo.42/3. This engine is cleared to operate at slightly increased r.p.m., and is being developed to a schedule roughly one year later than the RCo.42/1.

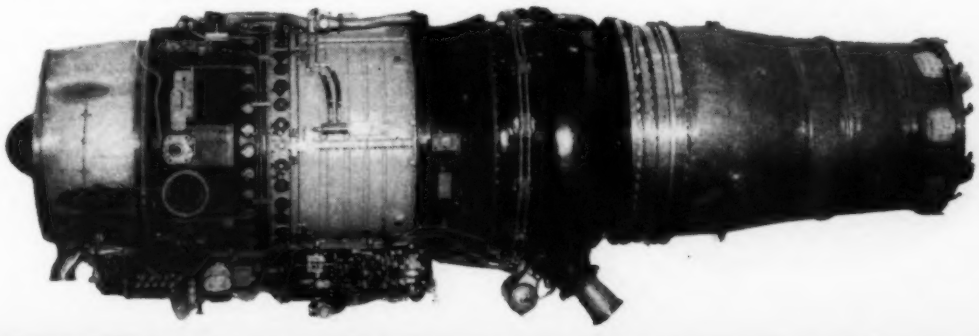
Dart Total Dart flight-time is fast approaching 20m hours, practically all of this being scheduled airline service. The most elementary Dart in current service is the RDa.3 Mk 506, overhauled by TCA on a 3,200hr basis. The uprated RDa.6 Mk 510 powers the majority of Viscounts now in service, and the several hundred such engines used by United (ex-Capital) are overhauled on a 3,100hr basis. All the latest Viscounts, and such aircraft as the Herald, Argosy, Gulfstream, and many Friendships, are powered by the RDa.7, with three-stage turbine. The RDa.7s of BEA have now also reached a remarkable 3,000hr time between overhaul.

Apart from the Dart Mk 21, in service in France and India as the powerplant of the Breguet Alizé, the first military version is the RDa.8 Mk 101, now delivered in considerable quantity for the 56 Argosy C.1s of RAF Transport Command. Essentially this engine is an RDa.7 with a 65°C increase in flame temperature and a water/methanol system which boosts (rather than merely restores) take-off power. The guaranteed minimum ratings of the RDa.8 are 2,310 e.h.p. dry and 2,680 e.h.p. wet, the latter figure being maintained up to ISA+30°C. The latest Dart is the RDa.10/1, with a mass flow increased by 15 per cent, the same flame temperature as the RDa.8, and provision for a water/methanol boost system and a reversing propeller with a conical spinner. The increased temperature is in no way intended to reduce overhaul or ultimate life, and improved materials are used throughout the turbine, the first rotor stage having cooled blades in Nimonic 105. Interest is hardening in these engines, which have now been ARB/FAA certificated at the rating given in Table 3. Deliveries have already been made to Japan for the Namco YS-11, which should fly early next year.

RB.145 Development of this single-shaft turbojet has gone ahead steadily during the past three years. Originally it was basically a long-life RB.108 equipped for manned aircraft operation, but compared with that engine it has a zero-stage on the compressor and a number of other major modifications. The latest version which can be divulged was exhibited at the recent Paris Salon, where it was emphasized that it has a number of applications in both propulsion and lift fields. Dry rating is 2,750lb. It may have been of engines of this type to which the Rolls-Royce chairman referred last month when he said "During the year [1960] we received contracts from Germany for the development of two versions of small engines of advanced design for military aircraft programmes." One of these engines is unofficially said to be designated RB.153, and to have a rating of about 4,900lb.

Spey In this engine Rolls-Royce have synthesized all their tremendous knowledge of high pressure-ratios, high flame-temperatures, by-pass design techniques and commercial gas turbines generally. The result is what is confidently believed to be the most efficient powerplant in the world for propulsion at Mach numbers between 0.7 and 1,

de Havilland Gyron Junior DGJ.2 Mk 101 turbojet

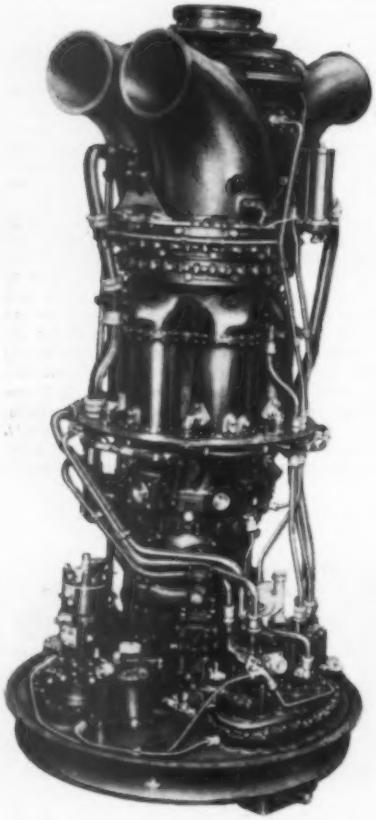


and it is likely to lead to a family of civil and military engines of very great importance. The design began when BEA asked for a smaller engine to match the scaled-down D.H.121 Trident in 1958. Rolls-Royce accordingly planned the RB.163 Spey, with a guaranteed minimum rating of 9,850lb. It is a curious fact that BEA signed their firm order for 24 aircraft three weeks before Rolls-Royce completed the design of the engine, in September 1959. Compared with earlier Rolls-Royce powerplants, the Spey has a higher by-pass ratio, a lower by-pass pressure-ratio, and a greater overall pressure-ratio than any other engine in production.

It is worth laying emphasis on the fuel system, which marks a reversion to first principles, and the adoption of an entirely new system in which the whole engine fuel flow is metered through large orifices in rotating sleeves. The resulting combined fuel control unit is very robust, is insensitive to dirty fuel and eliminates 80 per cent of the fuel-pressurized joints in the more complex systems of earlier engines. During rig-testing and runs of complete engines it has demonstrated its ability to govern the powerplant with commendable precision. Cabin pressurization is effected by a direct bleed off the high-pressure compressor, and electric or pneumatic starting may be specified. The latter arrangement is employed in the Spey 1 for the de Havilland Trident, and over 125hr has now been run on a complete Trident nacelle at Hucknall. Seven Speys have been built so far, and bench time is of the order of 500hr. Flight-testing should start in September using a Vulcan, the Trident is due to fly before the end of the year and production deliveries are scheduled to begin at the end of 1962. Essentially similar engines are to go into production for the BAC-111 and Sud Caravelle Junior. None of these engines employs a water system, and, by the addition of demineralized water, refinement to the gas-path and the use of later blade materials, the rating could be increased to well over 11,000lb with no major change to the design.

Negotiations have for many months been in progress with the MoA regarding the military applications of this excellent powerplant. A development contract for the RSp.1 has been operative for some months, and last month it was announced that engines of this type are to go into production to power the Blackburn Buccaneer S.2. It should also be possible to evolve a very efficient afterburner giving an exceptional augmentation ratio, should a military application warrant such an addition. The Buccaneer 2 and other military applications are certain to require restressing of the carcase to withstand much higher ram pressures and temperatures.

Napier Gazelle free-turbine turboshaft engine



Tyne At about the time our 1960 review was written this superb turboprop was on the verge of a metallurgical problem, afflicting discs in the high-pressure compressor, which delayed the dependent aircraft programmes by several months. Eventually it was concluded that tiny variations in the manufacturing processes for the Tyne wheels could lead to a loss of properties which, although barely detectable, eventually led to catastrophic failure. The problem was completely solved only after an extensive research programme, but both the Vanguard and CL-44 are now in service with the RTy.1, RTy.11 and RTy.12.

The Trans-Canada Vanguards have the RTy.11, incorporating improved material in the high-pressure turbine blading to permit an increase in flame temperature, and a substantial improvement in cruise performance is reflected in the airline's block-speeds. The RTy.12 is the first of the later Tynes matched to rather lower cruising speeds than those of the Vanguard, and accordingly giving greater shaft horsepower at some expense in jet thrust. The military RTy.20 has a still higher flame-temperature, obtained without a change in blade material by merely reducing the overhaul life. The Tyne 21 and 22, both of which appear in Table 3, respectively power the Br.1150 Atlantic, with 16ft propeller, and the Transall C.160, with 18ft propeller. A special rating is being evolved to meet the unique propulsive requirements of the Westland Rotodyne, and investigations have shown that further development of the Tyne up to the region of 10,000 h.p. can be accomplished without increasing the frame-size of the engine.

VTOL Having successfully demonstrated the feasibility of the composite type of powerplant system, in which separate lightweight turbojets are employed purely for lift, Rolls-Royce are very strongly placed to reap a large commercial reward in this field in the years to come. The company's studies have been of immense breadth and depth, and although they acknowledge a definite place for the combined lift/thrust engine, their main development effort is undoubtedly applied to specialized lift engines, of which the outstanding example is the RB.162. At the SBAC exhibition last September the company pointed out the progressive increases in thrust/weight ratio which they had achieved, and said "a unit entering the development phase achieves the outstanding ratio of 16." This engine is almost certainly the RB.162, which was first officially referred to late in May when the Minister of Aviation announced that its future development would be hastened by co-operation between the British, French and German Governments. It may also have been a guarded reference to this remarkable engine when the chairman of Rolls-Royce Ltd recently spoke of the considerable interest being shown in his company's ultra-light VTOL engines "embodying revolutionary ideas and new materials."

Light Aircraft Engine Department

Shortly after our 1960 review was published, Rolls-Royce announced that they had purchased a licence to manufacture Continental piston engines. The absence of any competitive British units in this class has long been remarked upon, and Rolls-Royce were undoubtedly right in not trying to attempt new engines of their own design. The company's agreement gives them exclusive sales rights throughout Europe for all Continental piston engines, and exclusive manufacturing rights in Europe for all engines nominated by Rolls-Royce; engines not so nominated are made by Continental and sold to European customers through Rolls-Royce. The agreement also provides exclusive manufacturing and sales rights throughout Australasia, but for nominated engines only.

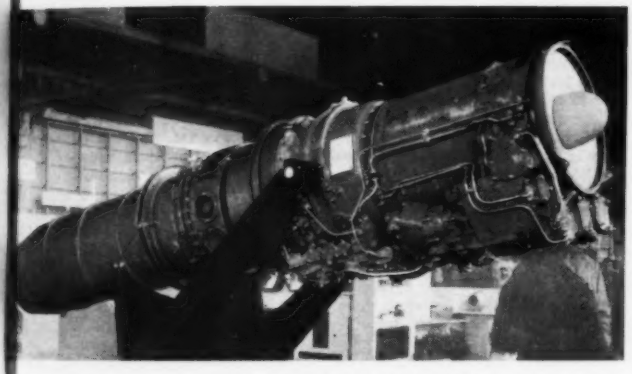
Manufacture has been entrusted to the *ad hoc* Light Aircraft Engine Department, which is part of the Motor Car Division at Crewe. This choice may appear strange, but Crewe are much closer to this sort of engineering than is the company's Aero Division. It may be emphasized that the British company will make "Chinese copies" of the US-built engines, since every spare must be completely interchangeable. Production is already starting on the O200A series of flat-fours to a variety of specifications to suit such aircraft as the Ambassadeur, Wassmer D-120, Rallye and Emeraude. The first of these engines is due for delivery in about a year's time, by which time manufacture will also have begun on all four varieties of the O300 series. The most advanced type of engine currently programmed will be in the 260-320 h.p. bracket. Rolls-Royce are not yet prepared to name the model, which will depend upon the prevailing demand, but the engine will certainly be one of the latest Continental designs with direct injection.

ROVER *Rover Gas Turbines Ltd, Solihull, Warwickshire.* Basing their work upon many years of experience with industrial gas turbines, which are widely employed not only on the ground but also in the airborne auxiliary powerplants for the Vulcan and Argosy C.1, Rover evolved the TP.60 and TP.90 turboprops to meet a requirement for an engine in this category for both new and existing single- and multi-engined light aircraft. The basic engine is an exceedingly simple and thoroughly proven unit, with electric starting and designed for operation on kerosine or diesel fuel. The drive is taken through a forward reduction gear to a two-blade propeller, which in the TP.90 installation is

hydraulically controlled. In the lower-powered installation a unique form of automatic pitch-variation is incorporated, described in our account of flying the Currie Wot equipped with this powerplant which appeared in our issue of February 10 of this year. In the opinion of this journal the Turbo Wot is "probably the smoothest, quietest light aircraft anywhere," but Rover are taking a long look before committing themselves to production.

Australia

CAC *Commonwealth Aircraft Corporation, Melbourne.* After producing 114 Rolls-Royce Nenes and approximately 200 Avons installationally matched to the Australian Canberra and CA.27 Sabre, the plant at Fishermen's Bend has been operating at much less than capacity for many months. Manufacture of new engines will begin only when all preparations have been made to meet the requirements of the SNECMA Atar programme for the Mirage IIIs ordered for the RAAF. Although present contracts call for only 28 aircraft, the total may eventually run into three figures, and Atar production should be substantial. The engine will be either the 9C or 9K, both described in the section dealing with France. Senator Harrie Wade, the Australian Minister for Air, said in May that a choice between the Atar 9C and 9K would be made "within four months."



Rolls-Royce RB.145 turbojet mock-up

Belgium

FN *Fabrique Nationale d'Armes de Guerre, Herstal-lez-Liège.* Having completed the manufacture of Rolls-Royce Derwents and Avons, FN are rapidly tooling up for the production of major components of the 1,300-odd General Electric J79-11A turbojets required by the European F-104G programme. This work, which is being undertaken in collaboration with BMW and Fiat, leaves the Belgian company with the prime responsibility for manufacturing the turbine rotor, compressor rotor, fuel nozzles, combustion liner, inner and outer casings and first-stage nozzle guide vanes. Ultimately, FN will be required to manufacture major portions of the Rolls-Royce Tyne RTy.21 for the Breguet Atlantic programme, and the company are overhauling the Orenda 11 turbojets of the CF-100 Mk 5 fighters, and the Turboméca Marboré turbojets of the Magister trainers, of the Belgian Air Force.

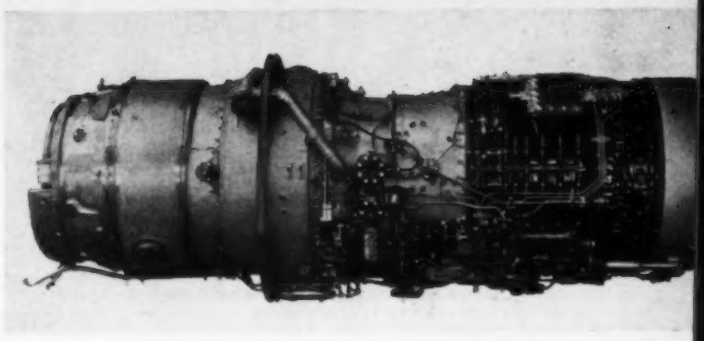
Canada

CANADIAN PRATT & WHITNEY *Canadian Pratt & Whitney Aircraft Co Ltd, Jacques Cartier, Quebec.* Having completed the manufacture of Wright R-1820 Cyclones for de Havilland's CS2F Tracker programme, the company's chief manufacturing programme is now the production of vast quantities of spare parts for Pratt & Whitney piston engines in all parts of the world. The company's own PT6 is described below. Canadian Pratt & Whitney handled the main design effort of the parent firm's JT12 turbojet, are producing the accessory gearboxes for the Canadair CL-44 and have overhaul facilities for all Pratt & Whitney engines used in Canada, as well as for the Wright R-1300 and R-1820 and the Napier Eland 504.

PT6 First shaft-turbine designed in Canada, this powerplant has been aimed at the business and private field above 200 installed h.p., while retaining "the usability and economics of the Wasp Junior." Lively American interest in the engine is indicated by the fact that it has been given the designation T74 by the US Navy. It has a unique design configuration in that the power section is back-to-front, the annular intake and accessories being at the rear and the exhaust issuing from behind the propeller and reduction gear. Features include: fixed geometry; an integral oil tank between the intake and accessory sections; a Hamilton Standard JFC-50 automatic control system; pads for a starter/generator, vacuum and hydraulic pumps, tachometer and power take-off; and ready sub-division into four main sections for overhaul.

Both turboshaft and tuboprop versions are being developed. The latter, designated PT6A, has a compound-epicyclic reduction gear giving a final output drive up to 2,200 r.p.m. The inlet arrangement permits tractor and pusher installations to be selected at will, but in most turboprops a single inlet scoop can be utilized. The turboshaft PT6B has only a single stage of gearing to give an output at up to 6,230 r.p.m. It is suited to a variety of helicopters, VTOL platforms and surface applications.

Detail design began early in 1959; the first gas-generator ran in November 1959, followed by the first complete engine-run in February 1960. On June 25 a total of 1,725 hours of gas-generator running, including 1,200hr of complete engine running, had been completed. Component and rig testing totals over 6,600hr. One of the eight PT6 engines currently in the development programme is installed in the nose of a Beech 18, which made its first flight during May. A series of 50hr company tests have been carried out, and the 50hr PFRT is scheduled for completion during the summer.

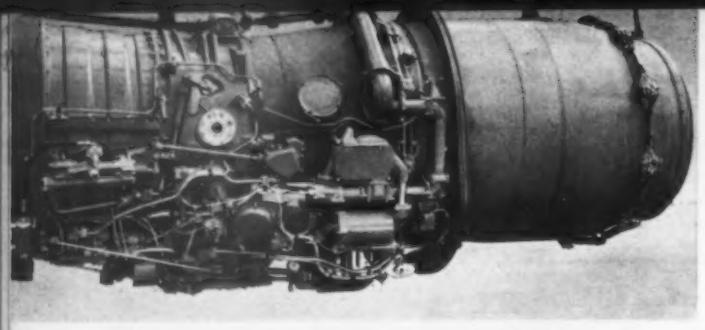


Rolls-Royce Avon 532R commercial turbojet

ORENDA *Orenda Engines Ltd, Toronto, Ontario.* This major member of the Hawker Siddeley Group is making efforts on a wide front into the research, design, manufacture and marketing of gas turbines for practically every conceivable purpose, including lift fans, industrial applications and nuclear powerplants. Over the period 1952 to 1958 total deliveries of all series of the Orenda engine amounted to 3,794. The final variants were the Orenda 11 for the CF-100 Mk 5 and the Orenda 14 for the Sabre 6, both rated at 7,500lb dry. The Orendas are still being used by five air forces in four continents and have accumulated a total of approximately 2m flying hours. Orendas are being operated at a rate of some 30,000 flying hours per month, and have a current overhaul life of 400 flying hours on the latest versions. The company's chief task on the manufacturing side is the production of the J79-OEL-7 turbojet, of General Electric basic design, to meet the propulsion requirements of the 200 CF-104 fighters being built by Canadair for the RCAF Air Division in Europe.

J79-OEL-7 This engine is a "Canadianized" J79. Detailed information, including engine and tool drawings and specifications for the J79 engine, were received from General Electric at the end of October 1959. The first engine was built and submitted to test by December 20, 1960, and the first production engine was despatched to Lockheed Aircraft, which is supplying the 14 initial training aircraft to the RCAF, on January 19, 1961.

The J79-OEL-7 has a 17-stage axial flow compressor in which the inlet guide vanes and first six stages of stator blades are variable. The combustion chamber is of the cannular type consisting of a Chromalloy outer casing and ten Hastelloy flame tubes. The blades in the three-stage turbine are attached to the discs by the fir-tree method of fixing, the blades being mounted in pairs with two blades per slot. The afterburner manifold and spray bar are mounted on the outer and inner flanges respectively of the fabricated turbine frame. The tailpipe and variable exhaust nozzle are cantilevered from the rear of the spray bar assembly. Although initial orders for some components or materials have been placed in the US, the engine is now largely made up of components produced and manufactured in Canada. Flow times to procure the various components have been established by the Canadian sub-contractors, and imports for the J79-OEL-7 programme have been reduced to approximately 20 per cent of all requirements. A photograph of one of these Orenda-built J79s appears on page 85.



Rolls-Royce Spey Mk I turbofan mock-up

Rolls-Royce Tyne RTy.20 turboprop

AERO ENGINES 1961 . .

Czechoslovakia

OMNIPOL *Omnipol, Prague 3, Washingtonova 11 (national agency for aero-engines).* Brief details of the chief Czech powerplants have been contained in most of our seven previous annual reviews. The four engines available in this country, through Aircraft & General Finance Corporation Ltd, are the Walter Minor 4-III (£503, ex works), the Walter Minor 6-III (£791), the M.332 (£744) and the M.337 (£1,081). The M.332 and 337 are becoming increasingly of relatively greater importance, and the Czechs claim they have the highest power/weight ratio and lowest frontal area of any light-aircraft engines.

France

HISPANO SUIZA *Société d'Exploitation des Matériels Hispano Suiza, Bois-Colombes, Seine.* Apart from the repair and overhaul of the 1,600 centrifugal turbojets built by the company under Rolls-Royce licence, Hispano Suiza's principal engine business today is the manufacture of the production series of SEPR.844 rocket packages for the Mirage III. The company has a considerable volume of business in the fields of landing gears, rotor transmissions and hydraulic systems, and is tooling-up to manufacture the Rolls-Royce Tyne RTy.21/22 for the Br.1150 Atlantic and Transall C.160.

NORD *Nord-Aviation SNCA, Chatillon Sous Bagneux, Seine.* As one of the world leaders in the field of supersonic ramjet propulsion, Nord have developed a series of engines for aircraft and missiles for flight at Mach numbers up to 4. Nord have a broad programme of research into the propulsion of supersonic airliners by combination turboramjet systems, and hold a USAF research contract for work of a similar nature.

POTEZ *Société des Avions et Moteurs Henry Potez, 46 Avenue Kléber, Paris 16.* By carefully limiting their objectives, this famous company have achieved singular success in the field of light-aircraft engines. The first two designs described below have been built in quantity, and the new flat-six appears assured of a substantial future, although the Rolls-Royce production of Continental engines is bound to have an effect.

4D This inverted four-in-line unit is supercharged by a gear-driven compressor lying flat on top of the crankcase. As the powerplant of the Nord 3202 and 3400, output has been maintained at a steady 15 engines monthly, the last of 375 on order being due for completion by next November 1.

4E Described as "interchangeable with American engines of the same class," this most attractive flat-four is fighting hard for a substantial share of the European market for units in the 100 h.p. category. Total backlog at the beginning of the year amounted to 108 engines, but this has now increased slightly and may rise rapidly with the completion of agreements to market the engine through Cessna in the USA. Current production is running at the rate of 20 engines per month.

6E Derived directly from the 4E, this new unit has a Zenith fuel-injection system and is performing excellently during bench testing.

SEPR *Société d'Etude de la Propulsion par Réaction, Villejuif, Seine.* In addition to the design and mass-production of a wide range of solid-fuel boost and sustainer motors for missiles and research vehicles, this rocket company has for many years concentrated upon pump-fed aircraft-boost engines. The standard propellants have usually been nitric acid and furaline, but in the production SEPR 844 for the Mirage III the mixture is nitric acid and TR-0 or TR-4 kerosine. Weighing 495lb, the complete unit is installationally interchangeable with a fuel tank or other equipment, and gives 3,703lb thrust at 52,500ft. The production 844s are manufactured by Hispano Suiza.

SNECMA *Société Nationale d'Etude et de Construction de Moteurs d'Aviation, Paris 8.* Established in 1945 as a nationalized enterprise embracing four famous companies' aero-engine work, SNECMA is easily the largest aircraft-engine organization on the Continent, and the only one to have achieved success in the design and manufacture of large turbines. SNECMA has five principal establishments, with a total covered area of nearly 2.25m sq ft and a payroll of 9,000. Their fortunes in recent years have hinged largely upon the successful development and production of the Atar turbojet, which began life in 1945 as a basic BMW design of World War II. In 1959 SNECMA announced a nine-year agreement with United Aircraft, under the terms of which the American company have acquired 10.9 per cent of SNECMA's capital and are represented on SNECMA's board, in turn for which the French firm have a licence to manufacture spares and complete engines throughout much of the Pratt & Whitney range of piston and turbine powerplants. As a result, SNECMA are today building up a substantial business in the support of JT4A-9 and JT3D-1 engines for Air France, KLM, TAI and UAT, and French military J57s, and service-support is also being provided for aircraft equipped with R-2800 and other piston engines. Conversely, Pratt & Whitney are inside the Common Market.

Atar Production of this simple and reliable turbojet began in 1953 at a rating of 6,610lb. Many hundreds of 7,716lb Atar Es and 9,700lb reheat Atar Gs were delivered between 1955 and 1959. In 1956 SNECMA unveiled the Atar 8, in which a two-stage turbine and zero-zero compressor resulted in a striking increase in thrust and efficiency. This engine is now in production for the French Navy, and has already demonstrated excellent reliability in adverse conditions.

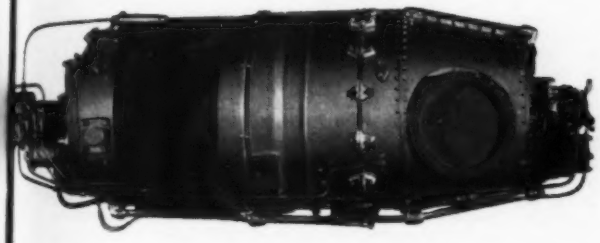
More important, however, are the afterburning Atar 9 versions. Powerplant of most of the Mirage IIIE and IIIR aircraft on order for the French Air Force will be the Atar 9C, with a large afterburner and ratings given in Table 1. A slight variation of this engine is the Atar 9D, shortly to go into production for the Mirage IVA supersonic bomber. Essentially the 9D is a direct refinement of the 9C, with slightly reduced weight and increased thrust. Modifications have been made to the control system, enabling the engine to give a substantially greater output at M1.4 and above, and operate at supersonic speeds for extended periods.

The latest version of the Atar is the 9K, the successful bench-testing of which appears to have been one of the chief factors leading to the selection of the Atar to power the Mirage IIIs of the Royal Australian Air Force. What SNECMA have done is to achieve transonic flow through the front of the compressor, by replacing the existing i.g.v.s, and the first two rotor and stator stages. A number of alterations have been made at the hot end of the engine, the flame-tubes having rearranged secondary air holes and the turbine rotor blades being of an improved vacuum-cast material of the Udimet 700 type. The resulting unit has a mass flow raised from 150 to 159lb/sec and a specific consumption "from three to five per cent better than that of the 9C." Guaranteed minimum ratings (sea-level, static) are 10,360lb dry and 14,770lb continuous with reheat. The engine first ran on the bench at Melun on April 15; during the past two months it has demonstrated short-period thrusts of 11,020lb dry and 15,430lb with reheat, and Australian representatives are watching progress. Delivery of production engines is scheduled to begin in November 1962, by which time SNECMA expect to incorporate titanium alloys into the engine.

M-35 This is unofficially given as the experimental designation of a SNECMA derivation of the Pratt & Whitney JT11. Rated at about 25,000lb dry, the M-35 engine is said to be one of the engines under consideration for the Sud-Dassault Super-Caravelle.

TF-106 The Pratt & Whitney JTF10 turbofan, derived from the JT8 turbojet, has been largely given to SNECMA for the French company to play with and find a market for. One JTF10 has been running on the bench at Melun since March, and its performance has been sufficiently encouraging for SNECMA to attempt to develop the engine much further. The TF-106 will incorporate most of the major assemblies of the JTF10, but will be modified to handle a larger airflow and incorporate fan burning. Rig tests are already in hand to determine the optimum design of injector and flameholder for the fan duct, and the problems of mixing the two hot streams may require lengthy experimentation—although SNECMA claim that a complete TF106 could run by June 1963. Design ratings are 11,240lb dry and 19,840lb with full reheat in both hot and cold flows. One family of TF-106 engines is being prepared for VTOL applications, with either gimballed mounting or tilting jetpipes.

TURBOMECA *Société Turboméca, Bordes (B.P.).* Although it may not be quite true to claim, as does the Union Syndicale des Industries Aéronautiques, that "Turboméca has been extremely clear-sighted in choosing low and medium power engines as their specialty, since these engines are somewhat neglected by the British and American companies," the fact remains that Turboméca has become the first name one thinks of in small turbine aero engines. No other company has achieved such commercial success in this sphere, and this is due to a happy combination of firm direction from M Joseph Szydlowski downwards, clear-cut commercial and design objectives, extremely effective application of a policy of rationalization of engine design so that critical components of the same design may be employed in a range of different types of powerplant, and liberal government support to ensure that the



Canadian Pratt & Whitney PT6B-2 turboshaft

company lacks nothing in the way of development and production facilities. Although the factory in the far Pyrénées has a floor area of under half a million square feet, and a total payroll of only 1,600, it houses some 760 of the finest machine tools, and output is currently running at a rate comfortably in excess of 100 powerplants monthly. In addition, production licences have been granted to Yugoslavia (1950-1), Continental, USA (1951), Blackburn, UK (1952) and ENMA, Spain (1954). Total production at Bordes amounts to some 5,300 engines, and more than 4,000 have been constructed by the company's licensees. The following are the most important of the company's current range of engines.

Artouste This family of turboshafts has been an outstandingly successful one, thanks to the wide acceptance of the Sud Alouette helicopter. At the beginning of 1960 a total of 610 Artouste 2B engines had been delivered, and 260 were on order for delivery at the rate of 20 engines per month. Further orders for the 2B and the very similar Artouste 2C have now taken production to some 1,030 engines (No 1,000 was delivered on May 29), and substantial production is beginning on the Artouste 3. All Artoustes are characterized by a lateral intake on each side and a forward wheelcase for accessories mounted above the main output shaft. The first production Artouste 2B was certificated in France in November 1957 and in the USA two months later. Minor improvements led to the Artouste 2C uprated to 500 h.p. but restricted to 400 h.p. to suit the Alouette 2 transmission and increase the engine life and overhaul period. This engine was fully certificated 18 months ago, and has been succeeded by the Artouste 2C3, in which the maximum take-off and continuous ratings are further increased to 550 and 495 h.p. respectively.

In 1954-56 Turboméca achieved a dramatic improvement in the performance of their engines by adding a transonic axial stage of compression ahead of the centrifugal impeller. The Artouste 3 is the first member in this new family of more efficient and more powerful engines, which are also characterized by a three-stage turbine. Compared with the Artouste 2 family, the new engine is longer but lighter, and runs at slightly lower r.p.m. The Artouste 3B is now entering production for the Alouette 3 helicopter, for which application peak output is limited to 543 h.p. This is also the maximum-continuous power, and can be maintained at up to 104°F at sea level or up to 13,800ft.

Astazou One of the most advanced of the company's axial/centrifugal range, the Astazou 2 is already in full production, and was certificated in January this year. Although there is a variant designated Astazou 2TM (*turbomoteur*) for helicopters, the existing applications are all for the Astazou 2TP turboprop, the outstanding characteristics of which have already led to wide acceptance in French, American, German, Swiss and other aircraft. A fundamental feature of the Astazou turboprop is its unusual control system, the desired r.p.m. being selected and engine power thereafter being varied entirely by use of the propeller-pitch control. When the latter is not moved, the powerplant is self-stabilizing, the s.h.p. being automatically balanced against airspeed. Essential safety features include automatic pitch limit-stops to prevent overspeeding, and a button-energized system which automatically maintains maximum power while adjusting propeller pitch to airspeed.

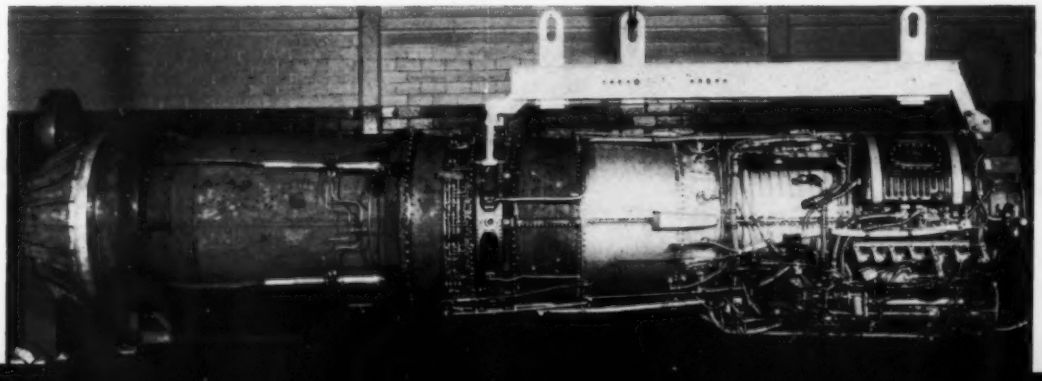
The Astazou has an annular intake casing, on the rear face of which are the powerplant pick-up points and a range of accessory drive pads. According to the requirements of the airframe, the reduction-gear ratio may be chosen to give an output at 1,800, 2,080, 2,200 or 2,400 r.p.m. to the Ratier-Figeac three-blade electrically controlled propeller. The first Astazou ran on the bench in 1958 at a design power of 414 s.h.p. This Astazou I was certificated at 463 s.h.p. at a turbine speed of 43,000 r.p.m., with a corresponding consumption of 293lb/hr. The Astazou 2 dates from 1960, and was certificated in January last. Development is now in hand on the Astazou 2 *Spécial*, which achieves its increased rating by having polished guide vanes and an increased flame temperature. No Turboméca engine has cooled blades.

Bastan Rapidly becoming the company's most important single powerplant, this turboprop was one of the first of the new family of axial/centrifugal engines. Its design-points are slightly less ambitious than those of the little Astazou, and the engine has proved an outstanding basis for development. The original design power was 650 s.h.p., but this had risen to 750 before bench-testing began, and the first certification, in January 1959, was at 805 s.h.p. After passing through the Bastan 3 level at 922 e.h.p., the Bastan 4 has now become the standard type of production engine, and the number on order is already well over 100.

SFERMA handle the task of equipping complete powerplants and effecting installations in new and existing aeroplanes. The standard Bastan 4 engine-change unit consists of a Ratier-Figeac three-blade propeller, annular intake with rear mounting faces for the engine and accessories, and a matrix-type oil cooler served by a ventral duct. Electric starting is standard. The engine was first flown last year, received its type certification on January 20, and on June 27 was stripped after having completed a cyclic endurance test of 1,000hr at the Hispano Suiza test establishment at Melun.

Marboré Built in much larger quantities than any other engine of Turboméca design, this simple turbojet dates back to 1951, and was first certificated in 1953 as a take-off booster. It soon found wide acceptance as a main powerplant, particularly in the Magister twin-engined trainer, total orders for which currently amount to 711, plus 30 of the naval version. Large numbers of Marborés have also been

Orenda Engines J79-OEL-7



SEPR.844 rocket pack

constructed under licence by Continental (*q.v.*), and in Spain. The basic Marboré 2 remains in production, with 2,000 delivered, but for export purposes is being superseded by the uprated Marboré 6. The latter first ran in 1959, and has been chosen for the Paris 2 and 3 and the Potez-Heinkel CM.191.

Palouste Manufacture of this bleed-air compressor unit is drawing to a close, although its success may be gauged by the fact that 150 Djinn helicopters have been sold to ten countries outside France. The standard version of the engine is the Palouste 4 (Table 5).

Turmo Starting in 1949 as a massively constructed unit for armoured fighting vehicles, the Turmo was the company's first shaft-drive engine, consisting essentially of a Palas turbojet with a free-turbine and rear output shaft. Redesigned for aircraft use, the Turmo has been built in Britain by Blackburn (*q.v.*) and small numbers have been manufactured in France. But the engine really came into its own when the addition of a transonic axial stage to the compressor opened the way to a dramatic increase in power and efficiency. This led to the Turmo 3 family, and today these engines are becoming the most highly rated of all Turboméca designs.

First of the Turmo 3s was the 3B turboshaft for the SA.3200 Frelon helicopter, which flew in June 1959 powered by three Turmo 3Bs each certificated at 882 s.h.p. But this was inadequate, both for the developed Sud 3210 Frelon and for the future Br.941 and 942 STOL transports, which were originally planned around the de Havilland Gnome. Gen de Gaulle decreed that a French engine should be used, and Turboméca have since been engaged in wringing progressively greater power out of the Turmo, without increasing the basic frame size.

The Turmo 3C turboshaft is the helicopter engine, with a direct pitot intake, upper and lower accessory drives around the front-support casing, twin exhaust ducts (upper and lower) taken away to left or right, depending on the installation, and a rear free-turbine driving through primary and secondary reduction gearboxes, the output from the primary gear being at 5,700 r.p.m. Development is in hand on the Turmo 3C2, in which power is increased to 1,282 s.h.p., for a fuel consumption of 816lb/hr. The turboprop is the Turmo 3D, and the Turboméca designers have followed the configuration established by de Havilland Engines with the Gnome. The main gas-producer is hung beneath the output shaft and can be removed as a unit. The rear free-turbine drives the upper shaft at 6,000 r.p.m., and the overhung forward drive leads through a freewheel and dog-clutch to the propeller reduction gearbox giving a final drive at 1,200 r.p.m. A drive pad at the rear of the primary box permits the powerplants of a multi-engined aircraft to be coupled together by spanwise shafting. This is a feature of the Br.941/942 aircraft, in which loss of one gas-generator means merely that less power is put into the four propellers. The 3D went on the bench last year and is now flying the first Br.941. Further uprating will lead to the Turmo 3D2, of 1,315 h.p.

Turbofan Turboméca have divulged no details of their new turbofan, beyond the fact that it incorporates certain components of existing engines and has a design rating of 1,540lb. Saab have stated that its specific consumption is exceedingly attractive, and that for this reason the engine has been chosen to power the Saab-105 multi-purpose light jet aircraft.

SNECMA Atar 8 turbojet

Germany

BMW *BMW Triebwerkbau GmbH, Munchen-Allach.* Aero-engine business on a large scale has been steadily built up in Munich during the past five years, the first major assignment being the licence-production of the Lycoming GO480-B1A6 piston engine, of which several hundred are now in service in the Dornier 27 and Focke-Wulf P.149-D. Gas-turbine experience was gained by contracts to overhaul the Orenda 14 turbojets of the 225 Sabre 6s of the Luftwaffe, and the largest orders of all are those for the manufacture of major components of approximately 550 General Electric J79-11A turbojets to meet the requirements of the European F-104G programme. Their partners in this operation are chiefly FN and Fiat. The units described below are of the company's own design.

BMW.6012 Developed from the familiar 6002, this tiny turboshaft unit is envisaged as a prime mover for aircraft propulsion or auxiliary power. Combustion begins after hand-cranking to 3,000 r.p.m., and the unit becomes self-sustaining at 10,000 r.p.m., normal operating limits being 20,000 to 45,000 r.p.m. According to the gearbox chosen, the output shaft may turn at between 3,000 and 8,000 r.p.m.; this 89 h.p. engine is described as "impervious to cold or to the kind of fuel chosen," and can be overhung as a cantilever from the unit being driven.

BMW.8026 Envisaged chiefly as a means of making gliders and sailplanes independent of winches or tugs, the 8026 turbojet weighs 84lb and consumes 4.4 gal of diesel oil in 25min. BMW suggest 15min for take-off and climb to 6,600ft, thereafter soaring with 10min power always available should lift be absent. The earlier BMW.8025 has proved most successful installed in the Allgaier H.30TS, and it is hoped that a wide market will materialize. Electric starting is provided for operation from the cockpit, lubrication is effected by adding oil to the fuel, and BMW claim that "in service no maintenance is necessary except refuelling."

KLOCKNER - HUMBOLDT - DEUTZ *Klockner - Humboldt - Deutz, AG, Cologne.* When the Federal Government obtained the Bristol Siddeley licence in respect of the Orpheus 803 turbojet, KHD were charged with its manufacture to power the German-built G.91s. The actual type of engine involved is the 803D-11, and now that tooling is completed KHD are at last in genuine production. The factory is in a built-up area, and a carefully sound-proofed test-cell has been built, starting in mid-1959. Functional checking of this installation took place in December last, and an Orpheus calibrated by Bristol Siddeley ran there in February. KHD are collaborating with Bristol Siddeley and with Fiat in the overhaul and manufacture of Orpheus spares.

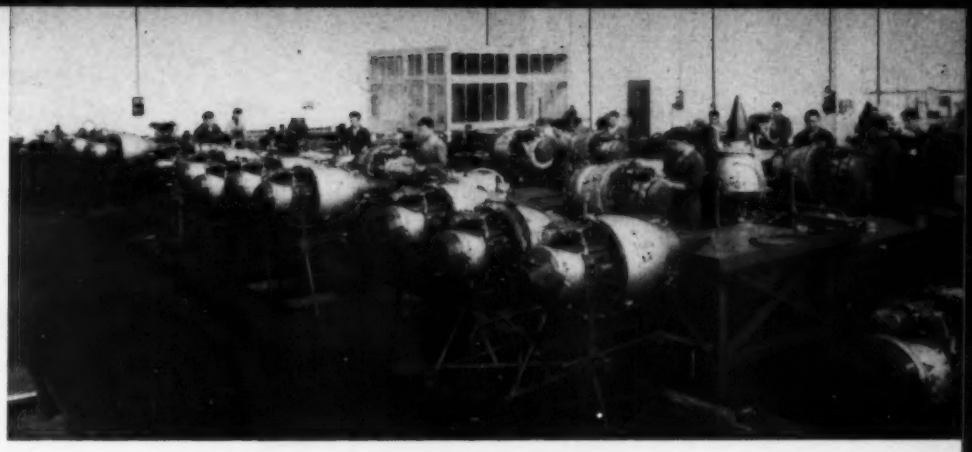
PORSCHE *Dr-Ing h.c. F. Porsche K-G, Stuttgart-Zuffenhausen.* Production is continuing on the various types of Porsche 678 flat-four piston engine, principally for the Jodel and other types of "home-built."

India

HINDUSTAN *Hindustan Aircraft (Private) Ltd, Bangalore District, India.* The production of Orpheus 701 and 703 turbojets under licence from Bristol Siddeley Engines has now started, in the new factory built for this purpose. Some of these engines are destined for Hindustan-built Gnats, but it is worth noting that a pair of Orpheus 703 flew last month in the same company's HF-24 supersonic fighter. Development continues with the PE.90H flat-four piston engine, which is progressively relying less and less upon American accessories and should shortly achieve certification at 90 h.p. Hindustan are responsible for the repair and overhaul of the several hundred Rolls-Royce Avons in service with the Indian Air Force.

Italy

AGUSTA *Meccanica Verghera Agusta, Gallarate (Prov. Varese).* This famous motor-cycle and helicopter manufacturer has steadily built up a line of most attractive horizontally opposed piston engines suitable for aeroplanes and helicopters. Details of the four principal types are given in Table 6, and new variants are under development. Agusta state that the four engines listed are "certified following CAR.13 American regulations and are sold all over the world."



Production of the Marboré turbojet at the Turboméca factory at Bordes

FIAT *Fiat S.p.A., Divisione Aviazione, Turin.* In addition to having a very substantial business in the manufacture of spares for established piston and turbine engines, Fiat's aero-engine activities now include the manufacture of two major powerplants of foreign design and the development of small gas turbines of their own conception. The latter are described below. The foreign units are the Bristol Siddeley Orpheus 803 turbojet and the General Electric J79-11, which is made in association with Alfa-Romeo and other firms to meet the requirement of the European Western Group of Lockheed F-104G manufacturers.

4004 After many years of experience with the earlier 4002 series, Fiat have embarked upon the Model 4004 turbojet, which consists essentially of the 4700 gas generator, described below, with the air compressor replaced by a propelling nozzle. Two types of 4004 have been designed, differing only in air-intake design. The original 4004.000 retains the 4700 intake, whereas the 4004.001 has a conventional turbojet intake. The latter is cast in Mg-Zr alloy, has three radial struts housing the front ball bearing and incorporates attachments for an oil tank above and accessory gearbox below. The data given in Table 1 refer to this engine; the 4004.000 prototype is nearly an inch shorter, but 11lb heavier.

4301 Again derived from the Model 4700, this is a free-turbine shaft-drive engine. The engine is arranged back-to-front, like the Canadian Pratt & Whitney units, and an additional axial-flow turbine downstream of the basic gas-producer drives a reduction gearbox and propeller shaft.

4700 Designed to power Fiat's own Model 7002 cold-jet helicopter, which has done many hours of tethered running, the 4700 is a unique gas-turbine engine in which the basic powerplant comprises a centrifugal compressor, mixed-flow annular combustion chamber and single-stage turbine. The unit is arranged in an upright position, and to its lower end is attached an additional axial turbine driving a magnesium-alloy centrifugal compressor which feeds fresh air up to the rotor. The engine has done its development running on JP-4 fuel, and is in receipt of financial support from MWDP and the Italian Air Defence Ministry. The 4700 was type-tested last year, and several development engines are now running. Data are in Table 5.

METEOR *Meteor S.p.A., Monfalcone.* The Alfa series of light piston engines manufactured at Monfalcone (Trieste) are two-stroke engines with feeding and scavenging by Roots-type blowers, and fuel injection either into the supercharger or directly into the cylinders. A family of engines has been built up with air-cooled cylinders in X-formation viewed from the front, the more powerful members of the family having an identical set of cylinders mounted immediately behind the first. Various versions are available to each basic design, some being highly rated for service in targets and drones, some being arranged for helicopter propulsion or with turbosuperchargers to give constant power from sea level up to 8,000 or 20,000 or 26,000ft, and at least one member of each design having full civil certification. Ratings of three types are given in Table 6.

Japan

ISHIKAWAJIMA *Ishikawajima Heavy Industries Co Ltd, 1010, Tanashi-Machi, Kita-tama-Gun, Tokyo, Japan.* After cutting their teeth with large contracts for the repair and overhaul, including spares-manufacture, of General Electric J47 turbojets installed in Mitsubishi-built Sabres and other aircraft, this large industrial company has for some months been busily engaged in tooling-up to manufacture the J79-7 turbojet to power the Mitsubishi-built Lockheed F-104J, a total of 177 of which are at present on order. The company are also manufacturing the Nippon YJ3-3 turbojet, the background to which was given in our review issues of March 18, 1960 and May 11, 1956. Although the YJ3-3 compares unfavourably with the Bristol Siddeley Orpheus powerplant of the Fuji T1-A trainer, it is envisaged that ultimately it will replace the British engine in the all-Japanese Fuji T1-B. Flight development of the YJ3-3 began in February 1960 with a unit mounted beneath a C-46D of the Japanese defence agency.

Poland

Between 1945 and 1955 the lack of any available aero engines, apart from the M-11 of Soviet design, frustrated Polish designers of light aircraft. Today the prospects are brighter, and several new engines are being developed at the engine design office of the OKL. Head of this office is Wiktor Narkiewicz, who was responsible for the 320 h.p. WN-3 7-cylinder radial, which has been in production since 1956 for the Bies trainer and is fitted to the four-engined MD-12. His WN-1 flat-four of 65 h.p. was temporarily displaced by the Continental C90, but the WN-1 is specified for a number of new aircraft under the 1961-5 programme. Also ordered for national projects during this period is the WN-6 flat-six, rated at 140 to 160 h.p. with direct drive and up to 185 h.p. continuously as the geared WN-6R. The latest design is the WN-7, rated at 110/125 h.p., which is essentially a four-cylinder version of the WN-6. No information is available on the OKL-developed turbojet, rated at some 2,200lb thrust, which is already flying in the TS-11 Iskra trainer, nor of the OKL institute's ramjet and pulsejet team under Wojcicki.

Spain

ENMA *ENMA, SA, Antonio Maura 4, 2°, Madrid.* Details of the range of piston engines produced by this national organization were given in our 1959 review, which was published on March 20 of that year. The company are in limited production with the Marboré 2 turbojet, under Turboméca licence, for installation in the locally built Hispano Saeta and Saeta Voyager. ENMA also handle the overhaul of the imported Turboméca Artoustes used in Aerotecnica helicopters.

Sweden

FLYGMOTOR *Svenska Flygmotor AB, Trollhattan.* Shares in Flygmotor are split 5:3 between Volvo and Bofors, but the company's chief occupation is the production of turbojets for the Royal Swedish Air Force. This work began with licence production of the RM1A (D.H. Goblin) in 1949-52, RM2 and 2A (D.H. Ghost) in 1952-5 and RM5 (R-R Avon 100 series) in 1955-8. The RM5 family are used in various types of Lansen aircraft, fitted with a British afterburner.

RM6 This is the designation of a series of turbojets based essentially upon the 200-series Avon, and mass-produced under Rolls-Royce licence for the J32B Lansen and all marks of Saab-35 Draken. The RM6 is fitted with a very effective afterburner of Swedish design, in which a bleed-air turbopump feeds from 1,000 to 7,000gal/hr for ignition by a hot-streak unit and control by a fuel-operated servo-valve to hold a constant pressure-ratio across the turbine. The latest members of this family of engines are based upon the RB.146 Avon 300 series, and such powerplants are fitted to the new variants of the Draken capable of over M2.

RR2 This ramjet was discussed in our June 1 issue reporting upon the Paris Salon. Although not an aircraft powerplant, it indicates the considerable technical competence of the Swedish company in carrying such a major project through to completion. Flygmotor have a technical agreement in this field with Bristol Siddeley Engines.

VR3 This liquid-propellant rocket engine was produced to meet a 1954 requirement by the Royal Swedish Air Board for a unit capabl

of boosting fighter-aircraft performance. Thrust was to be variable over a wide range up to 4,900lb at sea level. After taking a long look at nitric acid, it was decided to adopt HTP and JP-4, a decision which may well be gratifying to British workers in this field. Although work stopped in 1958, the specification was fully met, by an extremely simple pump-fed engine weighing 165lb dry.

USA

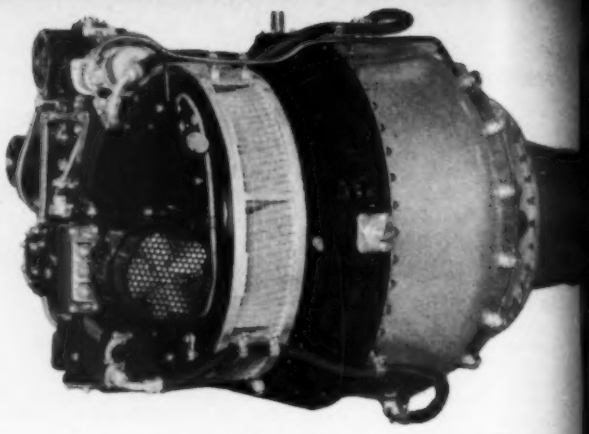
AIRESEARCH *AiResearch Manufacturing Co., Division of The Garrett Corporation, Phoenix, Arizona.* Long renowned for their very widely used series of small gas turbines employed for the provision of compressed air, shaft power or both, AiResearch were drawn into the aircraft-propulsion field in 1959 when McDonnell wanted are liable compressor to serve as prime mover in their Model 120 crane helicopter. Even then AiResearch had delivered nearly 4,000 GTC.85 engines, and its reliability caused three to be fitted to the helicopter to feed the rotor tip jets. As a result AiResearch have been encouraged to develop the engine described below.

Model 331 The GTP 331 is the first engine designed by the company with aircraft propulsion as the primary objective. Its layout is exactly like a Dart RDa.7, with two tandem centrifugal compressors driven by a three-stage turbine; but the 331 is a notably compact little engine, with a direct annular intake, annular combustion chamber with ten high-pressure nozzles, turbine inlet temperature up to 1,720°F on to 713C cast blades, and full provision for accessories (which are included in the weight given in Table 2). Front or rear output can be provided, and a reduction gearbox will be provided according to the aircraft requirement. Specific consumption is given as 0.64 at take-off power on the bench, and AiResearch have great hopes for the engine. It has already exceeded its design point specifications, and development should be completed by the end of 1962.

ALLISON *Allison Division of General Motors Corporation, Indianapolis 6, Indiana.* Although the T56 and Model 501 turboprops are performing satisfactorily in both military and commercial service in all parts of the world, the future of this programme appears to be a relatively limited one. Allison have for many months been negotiating with Rolls-Royce, on both technical and commercial grounds, and have even produced Americanized versions of such engines as the Spey and projected Conway 7, but it is now unlikely that any workable agreement is likely to benefit the two companies. In the aircraft-propulsion field the various types of Model 250 may be the only new source of business, although the PD-37 Pyrodyne ramjet system may ultimately be manufactured in very great quantity for the propulsion of supersonic targets and drones. Allison have won substantial contracts for the manufacture of cases and nozzles for large solid rocket motors, are heavily committed to research in the nuclear-rocket field for the USAF Systems Command, and recently announced a spaceflight auxiliary-power system using the Stirling cycle.

Model 250 Sponsored jointly by the US Army and USAF, from 1958 onwards as the T63, this engine is unusual in several respects. The sheer size of General Motors has enabled the development programme to proceed methodically without ever being starved of funds, and the probable scale of future sales—which could run into tens of thousands of engines for air, ground and marine applications—is being carefully considered, and may enable a unit of advanced design to be sold for a price of less than $6,000.

Allison have evolved a method by which complete compressor rotor stages are precision cast in an aluminium/cobalt alloy or reinforced plastic, the resulting assembly of disc and blades requiring virtually no machining and costing less than a third of an equivalent part produced by any other method. From the precision-cast centrifugal stage the air is delivered through a vaneless diffuser to a collector scroll, thence passing to the rear through lateral pipes to the single combustion chamber. The hot gases move forward through the gas-generator and power turbines, and are discharged through an exhaust hood projecting downwards. Backbone of the engine is the gearcase; the compressor is bolted on the front, the combustion chamber to the rear, and inside is the train of spur gears which take the power to an upper output shaft turning at 6,000 r.p.m. From the latter, drives can be taken to front or rear, and in the turboprop version a planetary reduction gear provides a final output at 2,000 r.p.m. An additional train from the gas-generator assembly provides drives to the accessory pads on the front and rear faces of the gearcase.

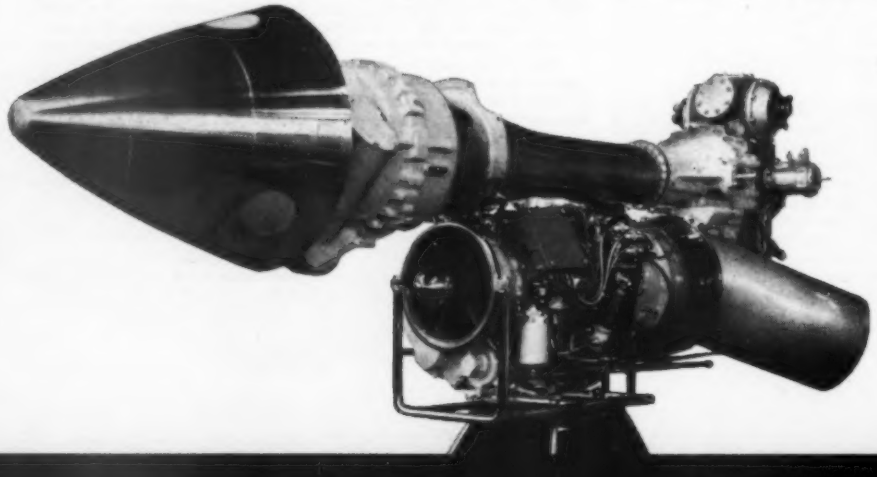


Fiat 4004 turbojet (exhibition mock-up)

Ratings for the Model 250 given in Tables 3 and 4 do not make it clear that the flame temperature is deliberately restricted under normal conditions to less than 1,760°F. As a result all versions of the powerplant can give their full output of 250 s.h.p. at up to 100°F ambient, the only effect on the engine being a rise in turbine-inlet temperature and specific consumption. No applications have been announced for the turboprop 250-B2 version, nor for the projected Model 252 powerplant consisting of a pair of power sections attached to a common gearcase. The turboshaft 250-C2, however, is specified as the powerplant in both the Hiller 1100 and Bell D-250 helicopters, which are the joint winners of the US Army's design competition for a new four-seat light observation helicopter; and many other applications are in prospect.

Model 501/T56 Sharing essentially the same power section and remote-mounted propeller gearbox, the commercial 501-D13 and military T56 was the first family of turboprop engines developed in the US to achieve any degree of success, and well over 1,000 of each type of engine have now been delivered. As the powerplant of the Lockheed Electra, the 501-D13 entered service in January 1959 at an FAA-approved overhaul life of 800hr. Late in 1959 the engine became the only gas turbine not of British origin to achieve a genuine 1,000hr overhaul life, without intermediate inspections. The time between overhauls has steadily climbed until earlier this month it was announced that the engines used by Pacific Southwest and Western Airlines have been cleared to the excellent figure of 1,800hr. Braniff and Eastern are at 1,600, American and National at 1,400 and Northwest at 1,200hr. By April of this year the 501-D13 had logged 2,300,000 flight hours in scheduled service.

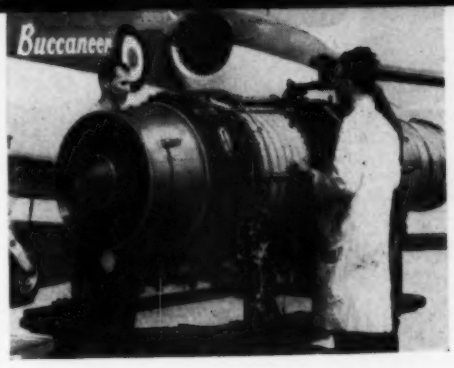
Production has ceased on the original military T56-1A and -9 engines installed in the Lockheed C-130A. In their place have come the T56-7, rated at 3,755 s.h.p. (4,050 e.h.p.) and driving a four-blade Aeroproducts propeller in the C-130B and C-130E, both of which are the subject of substantial production contracts. A similarly rated engine is the Navy T56-8, but the installation in the Grumman W2F Hawkeye is a complex one peculiar to the unusual requirements of this aircraft. The most powerful of all Allison turboprops is the T56-10W, which incorporates a water-injection system and other detailed improvements to give a maximum rating of 4,585 e.h.p. It differs from all other military T56 engines in having the propeller gearbox mounted below the axis of the power section; this is because the engine is installed in the Lockheed P3V-1 Orion, the ASW version of the Electra.



Turbaméca Turmo 3D turboprop (exhibition mock-up)

Flight, 20 July 1961

GNOME
GYRON JUNIOR
SPECTRE
GIPSY



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HOW ARE THINGS SHAPING AT SHANNON?

Why is Shannon so important?
There are three principal reasons. Shannon Airport is World-renowned as a transit stop for trans-Atlantic traffic. It is a Customs-free airport, the first to be opened in Europe. And it embraces the World's first air cargo industrial estate, using air freight well-nigh exclusively for the distribution of goods to World markets.

When was it established?
Construction of the airport began in October, 1936 but its runways were first opened to international and trans-Atlantic traffic after the war, on October 16, 1945. It became a Customs-free airport in 1947 and building construction on the industrial estate began about eighteen months ago.

How about Esso's history at Shannon?
In the early 1950's Esso, in close collaboration with the airport authorities, evolved and installed a hydrant refuelling system at Shannon—the first of its kind in the Eastern Hemisphere. And among Esso's airport staff at that time were those who had made much earlier refuelling history in that area when, in 1937 at Foynes, they refuelled the first trans-Atlantic aircraft to arrive there. That was a Sikorsky S-42 flying boat; eight years later the same crew refuelled the first trans-Atlantic landplane—a DC-4— to use Shannon Airport.

What's happening there today?
Some fifteen international airlines operate at Shannon, and already five carriers fly all-cargo services into and out of the busy airport. The demand for fuel is heavy and time is at a premium. Esso's installation is geared to meet this demand, with a staff of more than 50, a fleet of 16 vehicles including hydrant servicers and refuellers—and large-capacity Hydra-fuellers soon to come—combined with a hydrant system incorporating the latest developments and improvements. And Esso is prepared to meet the heavy future demands foreshadowed by current developments at the airport: developments which have changed its appearance noticeably in the past few years.

When did Shannon look like this?
This photograph shows Shannon as it appeared in the early 1950's.

In contrast, a glance at this recent view shows two new important features. In the background there is the new 10,000 ft. jet

runway, 006/24. In the foreground there is the new air cargo industrial estate which with the parallel development of a large residential community, has a long-term target to make provision for 30,000 people with 250 acres set aside for factories.

What is the significance of the industrial estate?
It represents a tax-free haven at a cross-roads of World-trade, enabling merchants and manufacturers to bring in materials for storage, manufacture, processing and assembly. Customs duties do not arise in the free trade area: and dispatch of finished goods to World markets is simply a matter of loading aboard an aircraft straight from factory shelves or parking line. Since production began in September, 1960 more than 250000 kg. of freight has been generated from the estate alone. By the end of 1961 this figure will have reached two million kg. and output may well be four times as great by 1965.

So what is the shape of things to come at Shannon?
A new look in air transport: increasing passenger traffic supplemented by a swelling volume of aerial freight. The big jet passenger transports soon to be joined by specially-designed turbo-prop freighters, and later by pure jet freighters, bearing bulk cargoes for transhipment at Shannon's new freight terminal for distribution by short-range freighters to European destinations. It is an exciting prospect for Shannon and for Esso, whose research scientists and design engineers, are already anticipating these trends, working ceaselessly to ensure that safe swift service in the Esso tradition is as fair a claim in the future as it is at Shannon today.

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Shannon Airport first attained importance as a flying-boat refuelling centre.

Irish International Airlines Boeing 720-048 Flagship "Padraig" (St. Patrick) receives fast Esso service from the hydrant fuelling system at Shannon.

We're flying the Atlantic . . . supersonic . . . *in a flask*

Not long ago the problem in jetliners was to prevent fuel from freezing. Shell research found the answer—the first low-freeze-point kerosine.

Now, with supersonic flight, the problem is heat. High temperatures in supersonic airframes, due to kinetic heating, affect the stability of conventional fuels.

In seeking an answer, Shell scientists simulate in a glass flask the atmospheric and temperature conditions which fuels would experience in supersonic flight. The effects are then measured by standard methods. Samples of metals used in aircraft fuel systems can be introduced to see how they influence the thermal stability of the fuel.

Research such as this is essential to the development of an economic fuel for supersonic flight.

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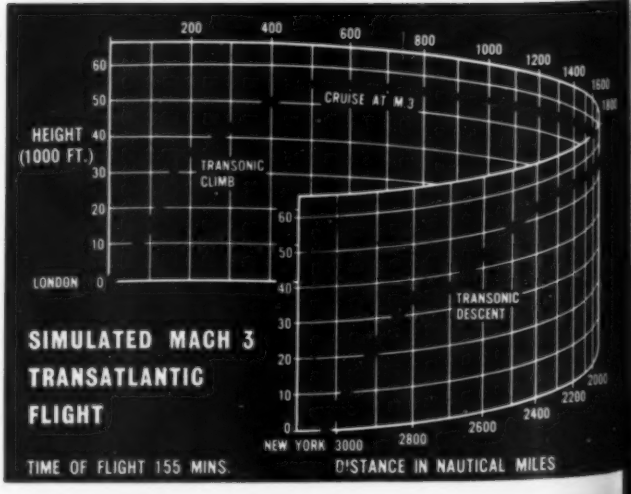
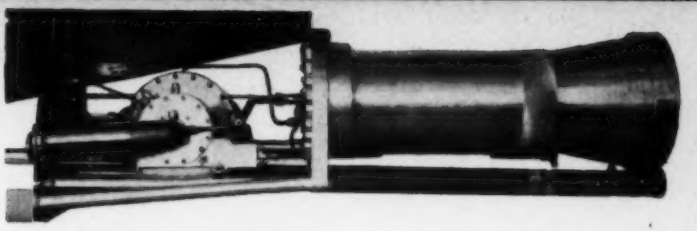
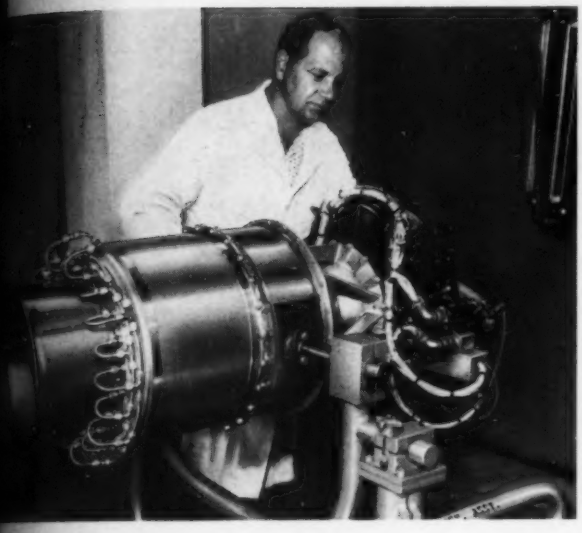




Svenska Flygmotor VR3 rocket engine

AiResearch Model 331 turboshaft



BOEING *The Boeing Company, Industrial Products Division, Seattle 24, Washington.* After working in the field of small turbines for 18 years, Boeing have established two basic designs of engine representing two generations of development. The first major production series of Model 502 engines started at 100 h.p. in 1947 with a specific consumption of 1.8, and now range from 240 to 360 s.h.p., with s.f.c. down to 0.89 and overhaul periods of up to 1,000hr. The most important aircraft-propulsion member of this family is the T50-4, now in production for the DASH (drone anti-submarine helicopter) built by the Gyrodyne Co of America. In March of this year this powerplant was approved by the US Navy after a 150hr qualification test at 270 s.h.p. with an exhaust gas temperature of 1,140°F without deterioration in performance.

The entirely new Model 520 is of appreciably more advanced design, and appears likely to give its rivals a run for their money. No applications have yet materialized, but the US Navy are sponsoring its development as the T60 and flight trials of the T60-2 turboshaft are shortly to begin in an unspecified helicopter. The Model 520-4 is the corresponding version for fixed-wing aircraft, and the 520-6 and 520-8 are still later engines due to become available by 1962.

CONTINENTAL *Continental Motors Corporation, Muskegon, Michigan.* Possibly the most successful producer of engines for light aircraft, Continental Motors describe themselves as "the world's largest independent manufacturer of internal-combustion engines." Their plant at Muskegon has a floor area of well over 1m sq ft, and from it comes a steady flow of flat-four and flat-six "Red Seal" piston engines of competitive design. At least two of the latest models are to be manufactured in the United Kingdom by Rolls-Royce (*q.v.*).

Smallest engine in production is the A65, rated at 65 h.p.; slightly larger are the C75 and C85, and the familiar C90 has now been supplemented by the later O200A, with rated power increased from 90 to 100 h.p. Among the flat-six engines by far the most important are the O470 family with a displacement of 471 cu in. The first production engines of this type were the O470K and L, each weighing 404lb and delivering 230 h.p. at 2,600 r.p.m. on 80/87-octane fuel, and the O470B and M, which are flatter and longer, 5lb heavier and develop 240 h.p. at the same r.p.m. using 91/96-grade fuel.

Both these engines have now been largely superseded by the IO series, with direct fuel injection according to an efficient Continental arrangement with low-pressure delivery from a rotary-vane pump. The IO470C is rated at 250 h.p. on 91/96-grade fuel and weighs 432lb, while the IO470D delivers no less than 260 h.p. at slightly increased r.p.m. (2,625) on 100/115-octane petrol for a weight of only 426lb. The IO470D is likely eventually to be one of the most important of the British-manufactured powerplants. All these engines are unsupercharged and ungeared, but a larger geared and supercharged engine, the GTSIO520, rated at 390 h.p., is approaching certification and has been quoted as the powerplant of the Short SC.7 Skyvan.

CONTINENTAL *Continental Aviation and Engineering Corporation, Detroit 15, Michigan.* Since the inception of its turbine programme in 1947, Continental Aviation has specialized in the development and production of small engines based upon the Turboméca Marboré, for which a production licence was obtained at the outset. As the J69, an Americanized Marboré went into production in 1951, and approximately 5,000 powerplants using the same basic gas-producer section have now been delivered from the production plant at Toledo, Ohio. Many of these units have been for non-propulsive applications, the most important of the latter being the Model 141 air compressor, well over 1,000 of which are providing ground support for advanced USAF aircraft, and the new Model 142 derived unit providing both air bleed and shaft power.

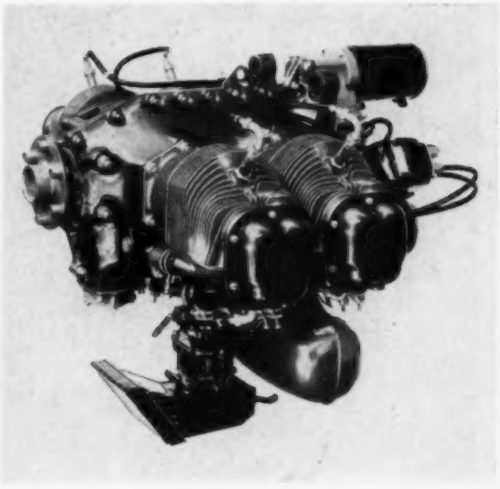
Small numbers of Artouste 2 turboshaft engines were delivered from about 1952 as the Model 220, and the latest in this series is the FAA-approved 220-5, which has successfully undergone a 1,000hr test at 400 s.h.p. (which can be maintained up to 95°F). Although there are no plans for immediate production, Continental have also discussed the manufacture at Toledo of the latest Turboméca powerplants, and their Models 231-2, 235-4 and 261-4 are respectively the Astazou 2, Bastan 4 and Turmo 3C, all of which are described in the French section of this survey.

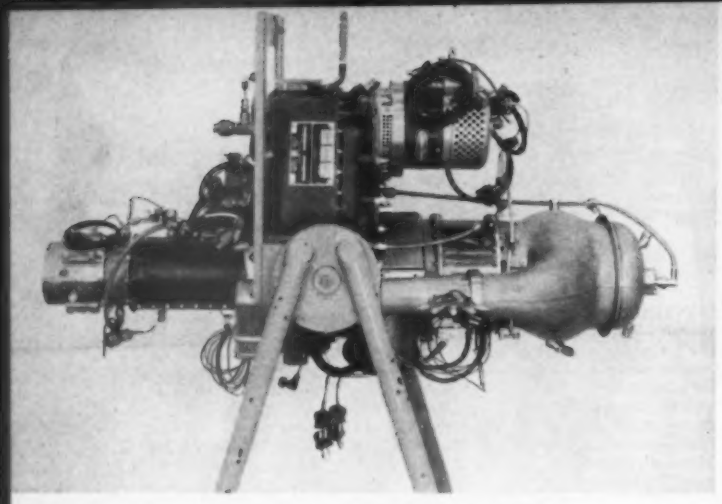
J69 Continental's first major production variant of the Marboré was the J69-T-9, several hundred of which were delivered for the Cessna T-37A at a rated thrust of 880lb. From these early J69s have been developed a succession of uprated variants. The first of these was the J69-T-25 (Model 1025) in which the air-handling capacity was increased to raise the military rating to 1,025lb. The increase was obtained by raising the r.p.m. from 20,700 to 21,730, and this also had the effect of increasing the surge margin. Many improvements were made to the fuel, lubrication, and accessory-drive systems. Many hundreds of T-25 engines are now in use in the Cessna T-37B.

In 1956 Continental followed the example of Turboméca and added a transonic axial stage upstream of the centrifugal compressor. This produced a startling advance in performance, and the first production version of the new family is the T-29, a highly rated unit in large-scale production for target drones (in particular the Ryan Q-2C and related Firebees). The T-29 is rated at 1,700lb at 22,000 r.p.m. with a specific consumption of 1.1 and an exhaust gas temperature of 1,300°F. Dry weight is 335lb and the engine has demonstrated its ability to operate at heights well above 60,000ft. Continental have derated this engine for manned-aircraft operation, the result being the commercial CJ69-1400 (no military designation yet applicable). Weighing 370lb, the Model 1400 has a guaranteed minimum thrust of 1,400lb at 21,000 r.p.m. with an exhaust gas temperature not greater than 1,175°F and a specific consumption not greater than 1.04.

T72 Otherwise known as CAE Model 217, the T72 is an entirely

Rolls-Royce Continental O200A





Allison Model 250 turboshaft

AERO ENGINES 1961 . . .

new powerplant being produced in turboshaft and turboprop versions. Although the words "entirely new" are deliberate, Continental have assembled the engine largely from proven components of the earlier production model: the compressor is that of the J69-29; the combustion chamber is common to that of most Continental turbines; the two-stage compressor turbine is that of the mass-produced Model 141 air compressor; and the single-stage power turbine is that of the J69-25 and -29. The basic unit is the USAF-sponsored T72-T-2 turboshaft unit with a 6,000 r.p.m. output. Around the intake diffuser is an accessory gear-train enclosed in a casing providing on its rear face drive pads for a wide range of equipment and the three engine mounting faces. Components of this engine have been on test for many months and at least one complete engine is now running on the bench. The entire design is regarded as conservative, suggesting that there will be no difficulty in providing the promised qualified flight-test engines early next year. Minor aerodynamic changes will permit early qualification at the increased rating of 600 h.p., and more extensive alterations will permit an increase in power to 850 h.p. without changing the engine frame size. Continental are also developing, with their own money, the Model 217-6A turboprop, with a maximum propeller speed of 2,100 r.p.m.

GENERAL ELECTRIC *General Electric Co Flight Propulsion Division, Cincinnati 15, Ohio.* This vast company studied gas turbines in 1895, built the first American (Whittle-derived) turbojet in 1941 and have now delivered more than 33,000 turbojets, more than any other manufacturer in the world. Today, the Large Jet Engine Department at Evendale (Cincinnati) is in quantity production with the military J79 afterburning turbojet, its commercial variant the CJ-805 and the aft-fan CJ-805-23. At one time the Flight Propulsion Division were one of the two prime contractors to the US Air Force for aircraft nuclear propulsion, but their X-211 direct-cycle powerplant was terminated by the President's decision to abandon all work in this field by June 30. Nevertheless, immense development effort is being applied to the J93 powerplant for the B-70 long-range bomber, and modest effort is also being applied to the military J79 aft-fan derivatives. The Small Aircraft Engine Department at Lynn, Massachusetts, are in quantity production with the T58 turboshaft and commercial CT-58, and the J85 turbojet both with and without afterburner. Development has reached an advanced stage with the CJ-610 turbojet, CF-700 turbofan and all forms of the T64 shaft turbine. The Flight Propulsion Division has also evolved from their aircraft powerplants a range of industrial and marine free-turbine units, ranging from the Model 720/722 of 900 s.h.p. up to the model 240 (derived from the J79) rated at 20,000 s.h.p. The model 240 will serve as primary propulsion for the Grumman hydrofoil, and is being offered in a 48ft airportable electric generator plant.

Removal of an Allison 501-D13 after 1,000hr on Eastern Air Lines

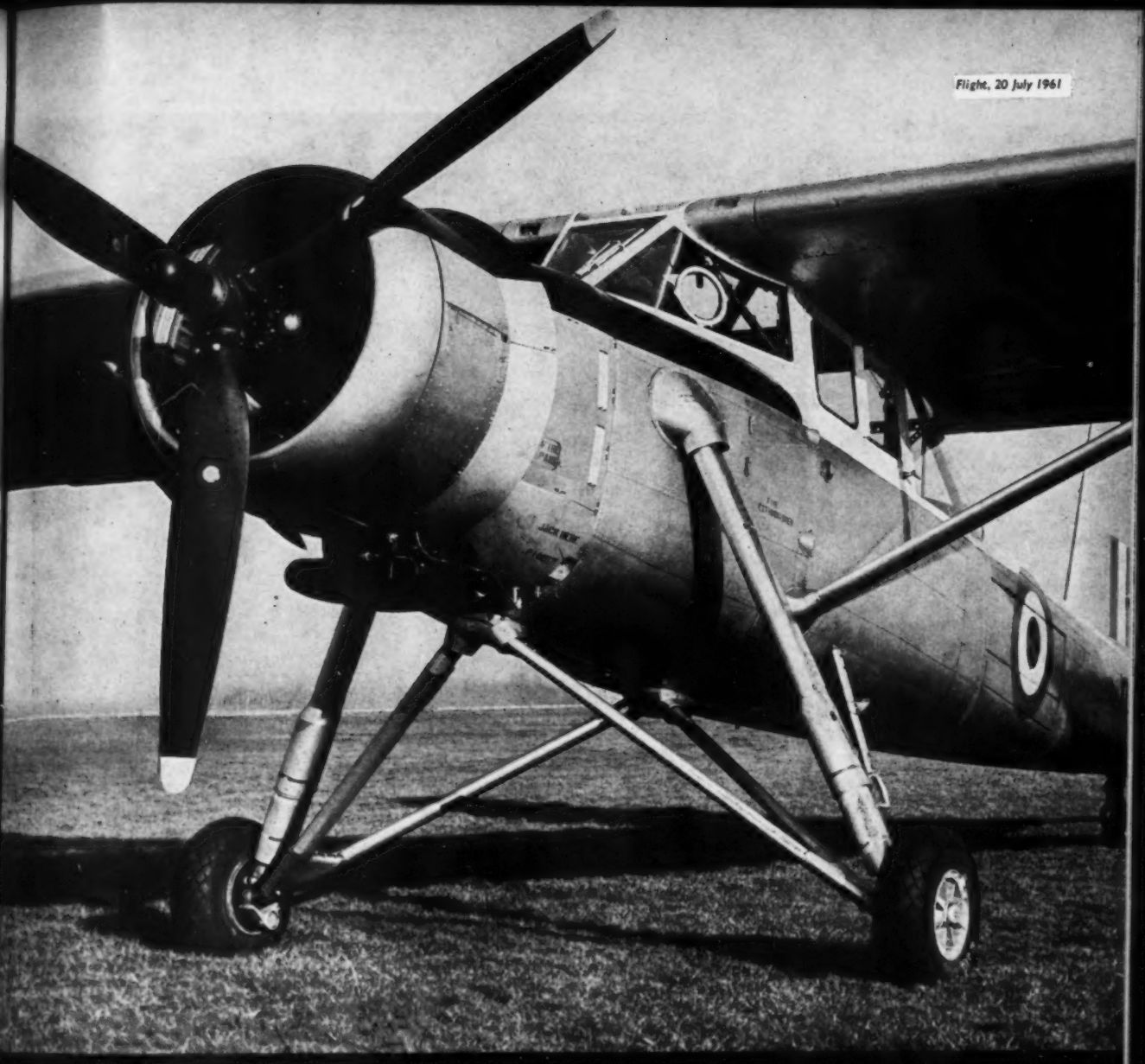
J79 In 1952 studies were initiated to determine the design of a new military engine to follow the mass-produced J47 and J73. Primary objectives were efficient performance at M0.9 cruise, the ability to provide propulsion at more than M2 and the desirability of reducing specific weight and specific consumption. The requirement for low s.f.c. during subsonic cruise implied a high pressure-ratio, and it was finally decided to adopt a single-shaft configuration and employ variable stators throughout the early part of the compressor to regulate airflow during off-design conditions. The intake guide vanes and first six stator rows are all mounted in rotary bearings and actuated by a ram pressurized with fuel automatically scheduled as a function of inlet air temperature and engine r.p.m. New lightweight constructional methods were adopted throughout the engine, outstanding examples being the wide use of thin steel sheet fabricated by precision welding and the conical turbine shaft which transmits 70,000 h.p. at peak r.p.m.

The J79 first flew beneath a B-45 in December 1955 and the J79GE-1 passed its 150hr qualification test and went into production in 1957. The first major production variant was the J79-3A, for the Lockheed F-104 A and B. Later models are listed in Table 1, and even more advanced versions are scheduled to go into production in the Fiscal Year 1963. This basic powerplant has served as the progenitor of the CJ-805 commercial turbojet and of various aft-fan aircraft and free-turbine industrial engines. The J79-11 is being licence-built in Canada, Germany, Italy, Belgium and Japan, for use in the F-104G, F-104J and CF-104.

J85 The Small Aircraft Engine Department began the MX-2273 lightweight turbojet in 1955 under a USAF contract to meet a requirement for a simple engine to power target drones and missiles. The demise of the competing Fairchild J83 increased GE's willingness to put money into the engine, and it has now materialized as a very successful military powerplant and as the basis for a civil turbojet and aft-fan engine. In its dry version (J85-7) the engine is in production for the Green Quail decoy missile, while the J85-5 with afterburner is in production for the Northrop T-38 Talon now operational with the USAF Air Training Command. More than 28,000hr of bench testing (incidentally, this is more than four times the current flight experience) have demonstrated that the engine can exceed its design specifications. The thrust/weight ratio of 7.5 is better than that of any other non-afterburning engine (excluding specialized lift engines), yet the SJ132 engine now on test achieves the remarkable figure of 10.5, increased flame temperature raising the thrust to 3,050lb and a number of structural modifications reducing the weight to about 297lb (270lb without fuel pump and control unit). The afterburning -5 engine has already demonstrated a thrust exceeding 4,100lb on maximum reheat, and on standard fuel has demonstrated numerous starts and protracted operations at ambient temperatures from −65° to 130°F at altitudes in excess of 30,000ft.

J93 Security restrictions still prevent the publication of details of this excellent single-shaft engine, six of which fit the propulsion bay of the North American B-70 Valkyrie long-range bomber. GE themselves are merely allowed to list the following facts: design objectives were low s.f.c. at M3 cruise condition, low weight and high airflow and thrust at M3 cruise condition; the compressor has a relatively small number of stages, with variable stators, and handles an extremely high airflow per unit frontal area; a convergent/divergent nozzle is used, with infinite variation to suit changing flight conditions; stainless-steel honeycomb sandwich (and other unusual manufacturing principles) are employed to reduce weight; and all accessories are contained in a controlled-environment pod mounted beneath the compressor and removable for maintenance as a single unit. Termination of the high-energy fuel programme two years ago did not affect the J93-3 variant selected to power the B-70, and a considerable number of development engines have logged something like 5,000hr on the bench and in a ram test facility at Evendale capable of simulating all conditions up to 2,000 m.p.h. at 90,000ft. Flight-testing up to M2.2 at 70,000ft is being accomplished with engines mounted in a self-contained and fully instrumented nacelle attached beneath a B-58A. Although it is not possible to duplicate the B-70 installation, the B-58 pod incorporates the same Hamilton Standard variable-intake control system.

CF-700 The Small Aircraft Engine Department have with company money developed this commercial aft-fan engine from the J85 turbojet. Since it is a commercial engine, the gas-generator is that of



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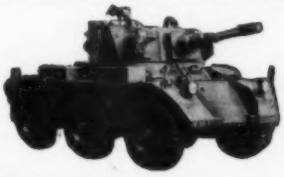
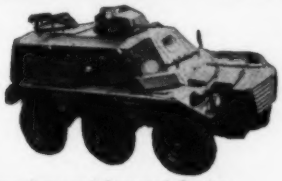


Saladin Armoured Car



Saracen Armoured Personnel Carrier

Stalwart Cargo Carrier

Left: Capt. J. A. Cameron, Manager BEA Helicopter Unit. Right: Mr. J. S. King Asst. Manager, Aero Sales, Sperry.

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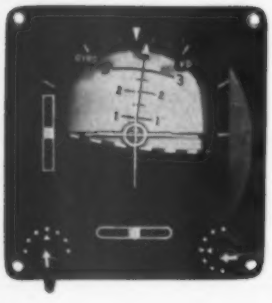

Four-Axis Spherical Director Horizon

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the CJ-610, and bench testing of a small batch of prototype engines has demonstrated that all guarantees can be met. Although no firm application yet exists, GE have a most competitive powerplant, which they are promoting vigorously for aircraft weighing between 15,000 and 60,000lb. Moreover, they expect the engine to find a natural market in later versions of the aeroplanes at present powered by the CJ-610. Certificated engines are scheduled for delivery early next year at a price of $75,000.

CJ-610 A direct commercial counterpart of the J85-7, the CJ-610 is available in two versions: the 610-1, costing $45,000, rated at 2,850lb and intended for aircraft weighing from 12,000 to 15,000lb; and the -2B, $5,000 cheaper, rated at 2,400lb for small aircraft down to 8,500lb weight. The accessory package and control system are based upon the equipment fitted to the J85-5, and prototype flight engines are available now. The CJ-610-1 has been chosen for the Aero Commander 1121, and the CJ-610-2B has been named as the powerplant of the SAAC-23 and Israeli B-101C.

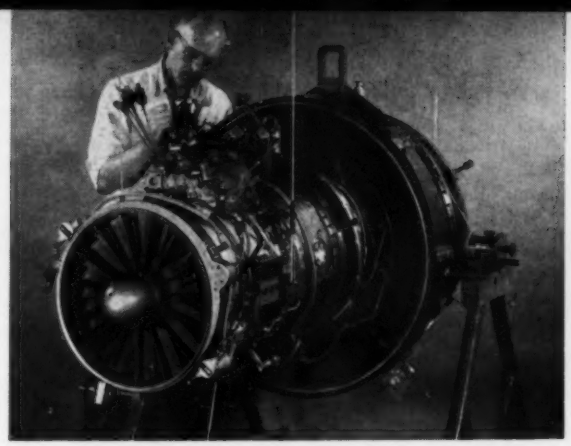
CJ-805 Derived directly from the military J79, the CJ-805 is a commercial turbojet, with a thrust/weight ratio higher than that of any other engine in airline service. GE developed their own fail-safe reverser and "daisy-ejector" suppressor as integral parts of the powerplant, and detail changes throughout the engine are aimed at improving its life and reducing the costs of overhaul in comparison with the military unit. The company financed a flight-test programme which involved an accelerated test of 1,000hr starting in April 1958 with one of the first CJ-805s mounted in an XF4D, and also included more than 3,000 flight hours logged by two engines mounted in an RB-66.

The FAA certificate for the CJ-805-3 was awarded in September 1958, and the Convair 880 powered by these engines commenced scheduled service in May 1960. Last December the -3 was cleared for 1,000hr between overhauls, and a further extension may be permitted before the end of this year. Bench and flight testing during 1958 indicated that aerodynamic and mechanical changes of a minor nature could improve the efficiency of essential components of the engine, and this has led to the CJ-805-3B, which handles the same airflow at reduced r.p.m. but has a slightly higher temperature. The -3B powers the Convair 880-M, which enters service late this year.

CJ-805-23 Although its designation is so similar to that of the straight commercial jet, the -23 series are the aft-fan engines in which a mechanically independent turbine/fan assembly is added at the rear of a basic CJ-805 turbojet. The fan assembly has a diameter of 48.8in and incorporates 54 double-deck blades operating at 950°F inboard and 200°F outboard. The outer fan blades are closely ducted, and in the Convair 990, the only production application, the duct is carried forward to an annular intake surrounding that for the turbojet. In the Caravelle 7 the fan duct has its own intake immediately ahead of the fan. Both aircraft have clamshell reversers, opening sideways on the 990 and vertically on the Caravelle. The aft-fan ran on the bench in 1957 and completed a 50hr test in December of that year. Approximately 7,000 bench hours have now been logged, and the highest-time engine has completed three 150hr endurance tests. Two engines which had already run 1,300 flight hours as CJ-805-3 turbojets were converted to -23 configuration and flown in the company's RB-66 in February 1960. The engine received its type certificate in June last year and is due to start scheduled service in the 990 next October.

CJ810 This engine was announced in May 1959 as a turbofan in the 7,000 to 9,000lb-thrust class, available for service in 1962. Nothing has been heard of it since that date.

MF-239C-3 Under this company designation a considerable programme of development has been in hand upon a 22,000lb-thrust aft-fan derivative of the J79 for subsonic military applications. The engine has been given the USAF number TF35, but does not appear to have any obvious market. Qualified engines could be delivered in July 1963.



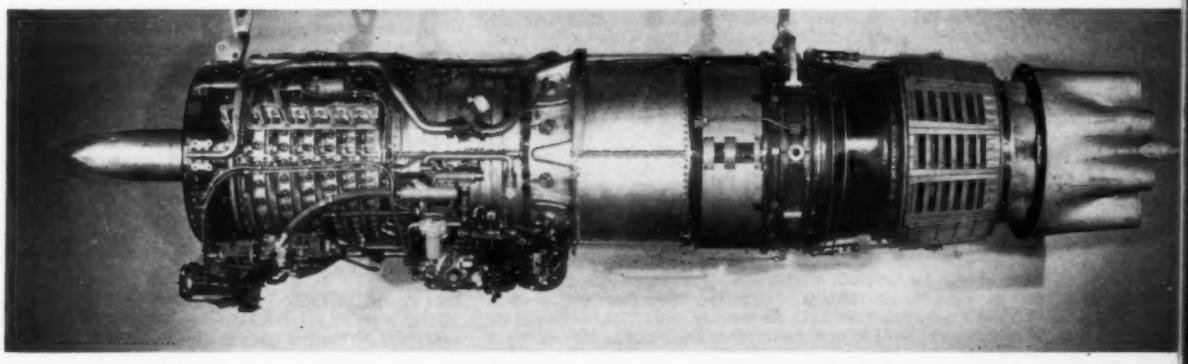
General Electric CF-700 turbofan

T58 Financed by the US Navy as a small turboshaft engine for helicopters, the T58 first ran in April 1955 and a pair of engines flew in a converted Sikorsky HSS-1 in January 1957. In February 1958 de Havilland Engines announced a manufacturing licence, and christened the British version, which differs substantially from its American parent, the Gnome (*q.v.*). Several hundred military engines have now been delivered from Lynn, principally for the twin-engine Sikorsky HSS-2, Boeing Vertol HC-1 and Kaman HU2K. T58s have been used in the Fairchild VZ-5 and Kaman K-16 VTOL craft. Current production has been largely of the T58-6, although minor changes to the hot end (in particular, first-stage turbine blading of improved material) led to the T58-8 rating now on the line. The -8 passed its 50hr PFRT test last year, ahead of schedule and exceeding all guaranteed figures.

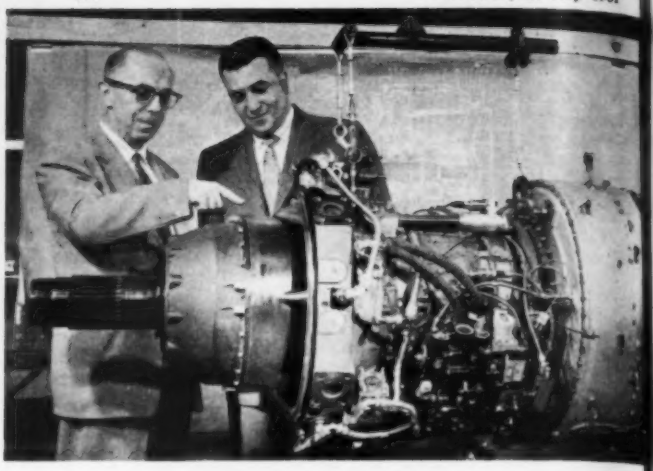
Commercial CT-58 Almost indistinguishable from the military engine, the CT-58 was the first American helicopter turbine to be certificated by the FAA. By the end of this year NYA, CHA and LAA will all be flying twin-engined helicopters powered by these units, operating them to an approved time between overhauls of 1,000hr. Single-engined S-62s are also coming into service in Los Angeles, San Francisco, Japan, and with a number of charter operators on the Gulf of Mexico, Canada, New Guinea and India. Including military operation, the 380 T58s shipped have logged over 60,000hr, of which 20,000hr is flight time, and should more than double this figure by the end of the year. Individual engines have completed 2,000hr without overhaul, suffered instantaneous loss of all load, and operated for sustained periods at more than 100°F above maximum permissible turbine-inlet temperature. Basic price is $69,000.

T64 Funded by the US Navy under an unusual contract calling for turboshaft, turboprop and direct-drive versions to be taken to the qualification stage and subjected to not less than 10,000 test hours, the T64 is nearing the end of its bench programme at Lynn, and should already have begun its flight-test programme. The basic engine is typical of the company's very efficient single-shaft, variable-stator powerplants, the pressure-ratio being set high enough to ensure a specific consumption comparable in terms of price with that of the best piston engines. The four basic versions have the military designations T64-2 turboshaft, T64-4 turboprop with reduction gear below the

General Electric CJ-805-3B commercial turbojet



General Electric J93 turbojet on simulated altitude test



Lycoming LTC4G-3 turboprop

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centreline, T64-6 and -6A direct drive and T64-8 turboprop with propeller above the centreline.

All versions can operate continuously in attitudes from 45° down to 100° up, making the engine suitable to V/STOL application. All models completed their PFRT stages last summer, and the 150hr qualification tests are about to begin. Other tests completed or in hand include simulated 1,000hr tests of 30min turboprop mission cycles, icing tests at all powers, environmental tests, including starting on JP-5 fuel at −33°F at a simulated altitude of 20,000ft or 130°F at sea level, and contamination tests on JP4 and JP5 with the fuel filters removed. The flight-test programme is already overdue, the T64-4 already being installed in a de Havilland Caribou. This aircraft is at present engaged in ground checkouts, and will now start its nine-month flight programme in August. GE have announced a programme to instal T64-8 engines in the Grumman Gulfstream, and many other flight applications are envisaged.

LYCOMING *Lycoming Division of Avco Corporation, Stratford, Connecticut.* While maintaining their position as one of the world's two leading suppliers of modern light piston engines for aeroplanes and helicopters, Lycoming Division have accomplished an extensive programme of research and development in a wide range of other fields. The LTC1 and LTC4 turbine engines are discussed below, together with some of the latest piston engines. Very large numbers of Wright R-1820 Cyclone piston engines have been manufactured for US military aircraft and helicopters, and production for the latest types of Grumman S2F and W2F is only now being completed. Other aeronautical activities include the development and mass-production of a number of major missile components, including the forward diffuser for Talos and complete chambers for some of the largest solid-propellant weapons. Piaggio in Italy hold a licence to make piston and turbine engines; BMW in Germany make the GO480 piston engine.

LTC1 (T53) Design of this free-turbine powerplant was initiated in 1952, the design power being 700 s.h.p. Emphasis was placed on the achievement of a conservative and trouble-free powerplant, and its excellent performance during bench and flight testing in 1956-9 has now won it wide acceptance in a variety of aeroplanes, helicopters and V/STOL vehicles. Altogether, the LTC1 family has accumulated more than 100,000hr of operating experience, practically all of this total having been logged by T53 engines of the US Air Force and Army.

Production of the T53-1 for the Bell HU-1A Iroquois and Kaman H-43B Huskie began in April 1958, and total flight-time is now of the order of 80,000hr, of which some 65,000 have been in the field. Current overhaul time was increased last December to 500hr, greater than that for any other small military turboshaft engine. The same engine, as the commercial LTC1B-1, was granted an FAA certificate exactly a year ago, although it does not at present have a commercial application. The T53-1 has been replaced in production by the T55-3 turboprop and T53-5 turboshaft, both of which run at slightly increased flame temperature and have appreciably higher rating. In turn, these units have been superseded by the T53-7 turboprop and T53-9 turboshaft, both of which are rated at 1,100 s.h.p. The T53-9 is already in quantity production for the advanced HU-1B Iroquois, no fewer than 242 of which figure in the Army's budget for the coming year. Test results on the -9 have in every case met or exceeded guarantees, making the engine the highest-rated fully qualified engine in its class. The FAA witnessed the qualification as part of the requirement for commercial certification.

LTC4 (T55) Bearing the military designation of T55, this unit was originally sponsored as a turboprop, the USAF funding the T55-1 from June 1954 onwards. The turboprop application gradually dwindled, but was replaced by the requirement for engines for the big Boeing-Vertol HC-1B Chinook helicopter. Although its configuration is identical with that of the LTC1, the LTC4 started as a rather more highly rated unit, and its power is more than double that of T53s at the same point in development, even though the newer T55 engine is only very slightly larger. The original T55-1 was rated at 1,600 s.h.p., but the engine was uprated first to the -3 power of 1,900 s.h.p. and now to the T55-5 rating of 2,280 s.h.p., at which level the engine is in production for the present Chinook.

Meanwhile, development of a fixed-wing version has continued, and dramatic proof of its potential is the recent announcement of the LTC4G-3 turboprop rated at 2,535 e.h.p. This engine utlizes a unique split-powered gear which fits on the front of the standard -5 Chinook engine. Developed with company funds, and the subject of a patent application, the new gear "is lighter, more compact and provides greater efficiency than standard two-stage planetary reduction gear trains." The system immediately transmits approximately one-third of the input power to the propeller shaft through the first-stage reduction gear, while two-thirds are transmitted by the second-stage. The new system also provides for a greater span between the propeller shaft bearings, resulting in better distribution of propeller loads transmitted into the engine casing. This should provide longer life for the complete gear train and shaft system. The new gear has been designed to be compatible with advanced versions of the T55 with power in excess of 3,000 e.h.p. The propeller is an Army-funded Aeroproducts unit. It can be seen from Table 3 that this engine has the highest power/weight ratio of any known turboprop. It continues Lycoming's building-block concept of making the same gas-producer serve any kind of output, and provision is made for what is described as "full nose-up operation."

Piston engines Work on reciprocating engines is centered at Williamsport, Pennsylvania, and both development and production is showing no sign of slackening. Great emphasis is being placed on direct-injection engines, and several such models have now received their FAA type certificates. Most important new family is a range of engines of 540 cu in capacity, data for the direct-drive, geared and supercharged versions being given in Table 6. The O540 family is used in the latest types of Aero Commander, and all these engines have direct injection. The smaller IO360 went into production last year for the Beech Travel Air, the IGSO480 continues in wide production, and the GO480 continues in production at Williamsport and in Germany. Among helicopter powerplants a major achievement was the award of an FAA certificate three weeks ago to the turbosupercharged TVO435, which is already in production for the Bell 47G-3B. Like the normally aspirated VO435, the new engine has a take-off rating of 260 h.p., but it can maintain this output to 15,000ft and can deliver a continuous output of 220 h.p. at 20,000ft. The turbosupercharger is the AiResearch T-1108, which incorporates an automatic control system regulating the exhaust flow through it.

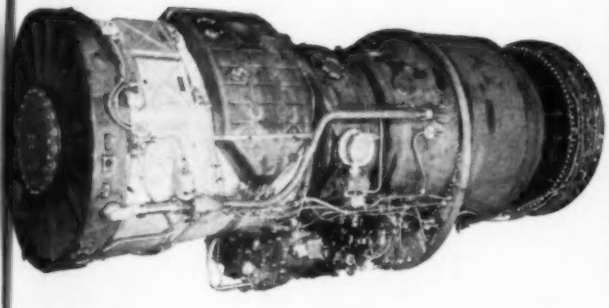
PRATT & WHITNEY *Pratt & Whitney Aircraft, Division of United Aircraft Corporation, East Hartford 8, Connecticut.* During the past year Pratt & Whitney have continued to dominate the aircraft-engine

market in the United States, and to provide worthy competition for Rolls-Royce elsewhere. Both companies have 38,000 people engaged in the design and production of aviation engines, and both companies are increasingly finding that it is "tough at the top." The American firm at least have the advantage of a substantial spaceflight business, although this is still largely of an R & D nature and therefore not particularly profitable. Basic gas turbines continue to be the staple product of the giant Connecticut plant, which now has a floor area rather greater than 7m sq ft.

With the exception of a promising range of single-shaft engines based on the Hartford/Montreal JT12, all present production powerplants for aeroplanes stem from the classic JT3 two-shaft turbojet, designed in 1947-9 and first run in January 1950. As the J57 this engine was by far the most important powerplant for both the US Air Force and Navy during the period 1950-60, and as the commercial JT3 it enabled Boeing and Douglas to design the world-beating family of "big jet" airliners. From the JT3 have been evolved the larger JT4 and the commercially astute JT3D series of front-fan powerplants.

During the past decade Pratt & Whitney have been one of the two prime contractors to the US Air Force on aircraft nuclear propulsion, and their work on closed-cycle systems at the USAF-owned Connecticut Aircraft Nuclear Engine Laboratory was at one time a major part of the company's activities. Early this year the President terminated all work on aircraft nuclear propulsion as from June 30. At one time the company made attempts to enter the ramjet business, but this has not materialized. Pratt & Whitney have, however, acquired substantial experience in the field of large liquid-propellant rocket engines operating on liquid oxygen and liquid hydrogen. This work, which is expanding dramatically in parallel with the gradual run-down of production of engines for aeroplanes, is based at the Florida Research and Development Center. The big JT11 turbojet is being developed at the same establishment—where ear-splitting noise is less of a problem.

JT3 Production of engines of the JT3 family started in February 1953, the first military J57s being rated at 10,000lb dry and 14,500lb with afterburner. Total deliveries today amount to more than 18,000 J57s and approximately 1,000 commercial engines. Total flight-time is of the order of 12m hours.



Pratt & Whitney JT4A-9 turbojet

Commercial JT3C The original airline variant was the JT3C-6, which entered service in October 1958. Development of this engine has long since been compleated, and its conservative design has resulted in a very satisfactory record of operation. It is in use in both the Boeing 707-120 series and DC-8-10 series, in both cases with reverser and suppressor. Present overhaul life ranges up to 1,800hr. From the C-6 has been evolved the C-7, in which removal of the water-injection system and redesign of the entire powerplant for subsonic transport operation has enabled the dry weight to be reduced by no less than 750lb. This version has been in operational service for some 18 months, and time between overhauls is at present 1,200hr. The projected C-10 (the C-7 plus water injection) has now been superseded by the C-12, which remains a dry engine but has an increased performance obtained by raising the flame temperature. The basic C-12 engine is identical with the C-7, and the conversion kit consists of little more than first-stage turbine blades of improved material (no Pratt & Whitney engine in production employs air-cooled blades). The C-12 will enter service later this year on the Boeing 720s of Eastern.

Military J57 Chief production engines are the JT3C-2 (J57-43WB) for the Boeing B-52G and JT3C-26 (J57-20) for the Chance Vought F8U-2N. The former is typical of the later military engines without afterburner, while the latter has a long afterburner weighing 900lb and a carcase stressed for flight at Mach numbers in excess of two. The latest model to come off the line is the J57-59W for the KC-135A and C-135A, and the backlog for J57s is still substantial.

JT4 This turbojet is not merely a scaled-up JT3, but is a fundamentally later design which introduced many features since carried across to the later members of the JT3 family. Total deliveries now amount to more than 500 military engines (all with afterburner) and approximately 1,000 commercial. Flight time is of the order of 1,500,000hr, about 80 per cent of which is commercial.

Commercial JT4 The original production version was the JT4A-3 certificated in March 1957 and used in the Boeing 707-320 and DC-8-20. The engine is approved at up to 1,400hr between overhauls, and its service record has been very satisfactory. Nearly two years ago it was replaced in production by the A-9, in which thrust is raised by 1,000lb as a result of the incorporation of improved materials in the inlet guide vanes and turbine rotor blading. The majority of A-3s have now been brought up to this standard, and the A-9 is operated at the same overhaul life of 1,400hr. Later this year deliveries will begin on the A-11, in which a further 1,000lb thrust is obtained by mechanical changes to the turbine section. The A-12 is a similar engine incorporating improved materials (in particular, a titanium low-pressure compressor rotor) which reduce the dry weight by 205lb, at some penalty in cost. Further development of the JT4 has not completely ceased, but the engine has been outclassed by the JT3D.

Military J75 All production engines of this type are in US Air Force service in the various types of Republic F-105 and Convair F-106. The F-106 still appears to have the J75-17, whereas F-105Bs and Ds have the JT4A-29 (J75-19W) with a water-injection system. Taking into account afterburning ratings only, these are the most powerful engines in service outside the Soviet Union.

JT3D The evolution of this extremely important turbofan was outlined in our 1960 review. Essentially, the JT3D is a JT3C with the first three low-pressure compressor stages replaced by a large diameter two-stage fan, and the low-pressure turbine altered and given an extra stage to provide the increased shaft-power required. The front-fan conversion is claimed to retain 90 per cent of the parts of the JT3C, and the latter can be converted into the turbofan with the aid of a kit supplied for the purpose. It must be admitted that no lash-up of an existing turbojet can ever quite equal in efficiency an engine starting as an uninhibited design, and the JT3D is no exception to this rule. The existing JT3C accessory package dictated that the fan air should be discharged as close as possible down-stream of the fan, and not only does this prevent the correct mixing of the hot and cold streams required for minimum specific consumption, but it also increases the difficulty of achieving complete thrust-reversal. Nevertheless, the engine is a thoroughly sound conception, and its wide acceptance by both military and commercial customers is sufficient testimony to the very considerable improvement in aircraft performance which it renders possible.

Commercial JT3D The basic JT3D-1 is now in service with American Airlines in the Boeing 707-120B, and is also coming into use on the 720B and DC-8-50. Engines are being overhauled to a nominal 1,000hr period, although a proportion are being "pulled" at 800hr following the usual precautionary practice pending the establishment of an official life. Now in full production, the JT3D-3 has hot-end improvements in order to permit operation at a higher flame temperature; this engine is due to come into service about next October. Development is continuing on the JT3D-5A, but this commercial engine appears to have been overtaken in development by the military JT3D-8A, and in any case does not yet have a firm application.

Military TF33 The military JT3D-2 is known to the US Air Force as the TF33-3, and is in quantity production for delivery to Wichita at the powerplant of the Boeing B-52H. No reversers or suppressors are fitted, and the fan air is discharged through a banana-section duct on the outboard side of each twin-engine nacelle. These engines are externally distinguishable from the airline powerplants by the prominent bleed-air pipes passing high over the fan casing to anti-ice the intake. Flight-testing began in the summer of 1959, and the following year eight of these engines flew in a converted B-52G. A number of production B-52H aircraft are now in the flight-test stage. Hot-end improvements, similar to those incorporated in the commercial JT3D-3, produce the JT3D-4, and it is intended that all TF33-3s will be brought up to this standard (military designation, probably TF33-5) during the coming year. Intensive development effort is now being applied to the JT3D-8A (probably to become the TF33-7), which has been adopted as the powerplant of the Lockheed C-141 heavy freighter. In many respects this largely new engine represents an acceptance of Rolls-Royce practice, and it has many points of close similarity with the Rolls-Royce Conway RCo.42. The principal mechanical changes introduced in the later types of military JT3D are found immediately downstream of the two fan stages. The first major development, in the JT3D-8A, is the replacement of the third stage of the original low-pressure compressor; and the next stage, in the projected JT3D-14, will be transformation of this row of blades into a third fan stage. Such a step will demand an increase in the diameter of the three-stage low-pressure turbine. All these new engines are re-dressed externally as a true turbofan, the accessories being grouped beneath a continuous fan duct leading to a reverser at the rear handling both hot and cold flows.

JT8 Originally this medium-sized turbojet was supported by the US Navy, so that its military designation is J52, an even number (Air Force engines have odd numbers). Its original application was the Douglas A4D-3 Skyhawk, development of which was cancelled in 1957. In August of that year the J52 was selected to power the North American

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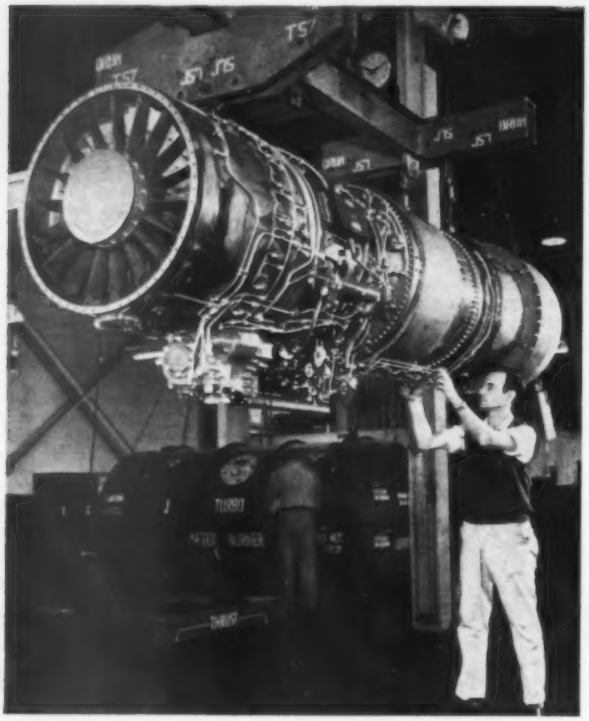
GAM-77 Hound Dog air-launched missile, and for this purpose an entirely different version of the powerplant was developed, with a rating of 7,500lb without an afterburner and optimized for flight over a wide range of Mach numbers and altitudes. Control and accessory systems of the Hound Dog engine differ considerably from those required for land aircraft, and unusual features of the installation are that a conical centrebody is mounted in the intake and a variable central plug in the propelling nozzle. In 1958 the J52-6 was funded by the Navy to power the Grumman A2F-1 Intruder attack aircraft, and a unique feature of this engine is that its jetpipes can be hinged downwards through 23° to increase STOL ability. The J52-6 has been the subject of at least two production contracts, and some dozens of engines have now been completed. Now the wheel has turned full circle, and the J52 is back in its original application, the Skyhawk. In many ways based upon the defunct A4D-3, the all-weather A4D-5 has a J52-6 or -8, with a conventional fixed jetpipe. No fewer than 180 A4D-5s are included in the Navy budget for the coming financial year (begun on July 1), far more than for any other type of aircraft. Components of the JT8 are employed in the JTF10 and have assisted in the development of the JT8D.



Pratt & Whitney J52-6 turbojet

Pratt & Whitney JFTD12 turboshaft

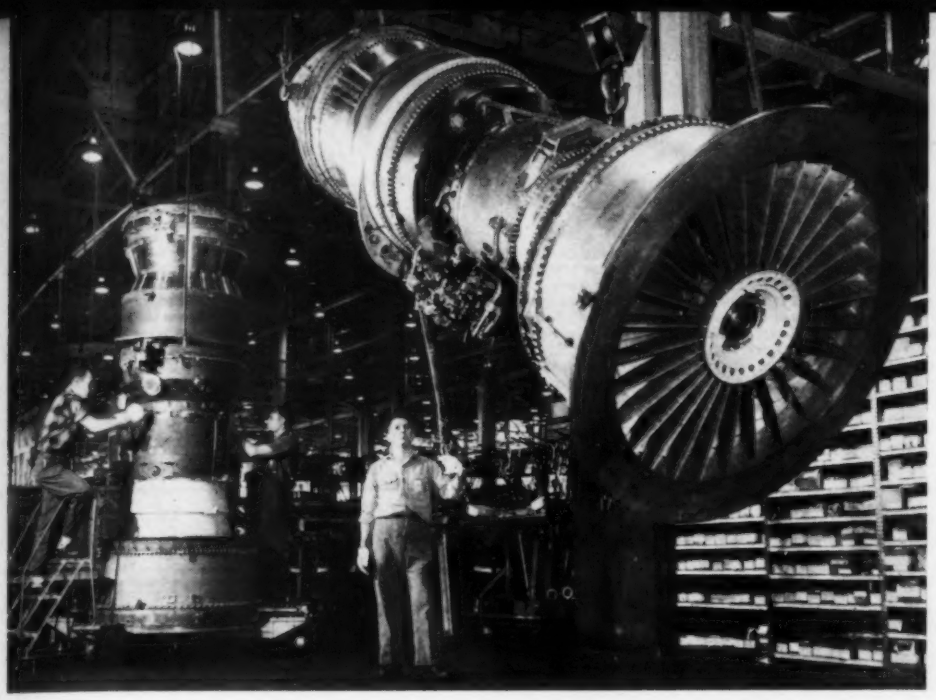
JT8D Discussed at some length in our June 29 issue, this powerplant has been carefully optimized to provide the most efficient possible propulsion for short- and medium-range transports. As has previously been remarked, its basic design parameters are essentially similar to those established by Rolls-Royce, but it differs from the British engines in having a rather lower pressure ratio, considerably lower flame temperature and a turbine split 1+3 instead of 2+2. It is instructive to compare the company cutaway drawings of this engine and the Rolls-Royce Spey which *Flight* has published.* The ruling materials throughout the JT8D-1 are steel and titanium, and their selection is claimed to minimize foreign-object damage and permit compressor-blade profiles which result in increased efficiency. All fan blading is of titanium; each blade is dovetailed into its disc and those of the first stage are provided with an integral shroud on either side, at about 61 per cent span, abutting against those on the adjacent blades. The flame tubes are conventional assemblies built up by welding together successive circular sections, the "bullet nose" contrasting with the unusual annular tubes disposed around the combustion chambers of the company's earlier engines. Further proof of the fact that this engine is not just a converted turbojet is the manner in which engine accessories are hung on the outside of the fan duct, the latter leading to the rear to exit around the hot jet. To minimize specific consumption a Rolls-Royce type of hot/cold mixer is included, and a single reverser and suppressor can be fitted. The JT8D-1 was specially tailored to the Boeing 727, and United Aircraft's licensees, SNECMA, have designed a complete nacelle suitable for both this aircraft and the projected Caravelle 10. The first JT8D drawings were released to experimental fabrication last November and the first development engine ran in April. At least two other engines have now run, and total bench time is probably of the order of 200hr. The first flight will take place in October, with an engine slung beneath a B-45; prototype delivery is due next May and first production delivery in February 1963. Some of the data given in Table 2 have not been published previously.

JTF10 This medium-sized turbofan was evolved directly from the original JT8, in 1958. All work on it has been passed across to SNECMA, the company's licensees in Europe (*q.v.*).

JT11 Described by the company as "a turbojet in the 30,000lb thrust class, intended for operation at high altitudes and high Mach numbers" this family of powerplants began as the Navy-funded J58, the design of which was completed in 1957. All the development of this powerplant has been handled by the Florida Research & Development Center, where about 30 JT11s have been manufactured and tested under conditions simulating Mach numbers of up to 3. The JT11 is a single-shaft engine of "moderate" compression ratio, and is in some respects reminiscent of the much smaller JT12. Hamilton Standard, another United Aircraft division, have developed for it a very advanced control system which automatically governs the variable intake, peripheral compressor blow-off valves, fuel supply for engine and afterburner and the configuration of the very large convergent/divergent variable nozzle. When we discussed the JT11 in our 1960 review it was still primarily a military project, although its only likely applications were projected developments of the B-58 and to act as a back-up to the GE J93-3 for the B-70. Today, the JT11 is regarded principally as a national "workhorse" development unit for the investigation of structures, control systems and complete propulsion installations for a 2,000 m.p.h. airliner. The afterburning ratings vary from 30,000 to almost 40,000lb (and far more at high forward speeds), but it is anticipated that the ultimate transport engine will not have an afterburner, in which case the dry rating will start at 23,000lb.

JT12 Designed largely by Canadian Pratt & Whitney, this single-shaft turbojet is sized to achieve the best possible thrust/weight ratio, and its brochure performance and demonstrated reliability indicate that it has become hard to beat in the 3,000lb thrust class. The company state that it was conceived "specifically for executive aircraft use"; but the truth is that, when it was designed, military applications, both piloted and unmanned, appeared to offer as good a potential market. Its design is true Pratt & Whitney, the basic engineering being conservative and amenable to considerable development. It was the first of the company's engines to revert to simple centre-injector flame tubes. Drawings were released in January 1958 and bench-testing began in May of that year. First flight took place in April 1959 beneath a B-45, a 50hr test was completed in August of that year and during 1960 the engine flew in the Canadair CL-41, JetStar, Fairchild SD-5 drone and T-39 Sabreliner, in that order. All guarantees have been handsomely exceeded, and—although the afterburning variant has no apparent

* *Rolls-Royce Spey, May 18, pp 670-1; JT8D-1, June 29, p 892.*



Pratt & Whitney JT3D-1 (left) and TF33-3 in the main plant at Hartford

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future—the basic engine is now in full production, the military designation being J60. The same gas producer has led to the engine described hereunder.

JFTD12 Announced in October last year, a new series of shaft-drive engines based on the gas-producer section of the JT12 turbojet appears likely to win a ready market in the 4,000 h.p. class. All members of this family consist essentially of a JT12 with a new free-turbine added downstream to provide a rear drive, the exhaust being taken out to one side. There is no government money in the engine, and Pratt & Whitney were prompted to develop it partly owing to its very extensive air, ground and marine market and partly since such a powerplant was urgently required by Sikorsky Aircraft, another United Aircraft division. Their S-64 Skycrane heavy-lift helicopter could not have been realized had the JFTD-12 not been available. In this application, a pair of the new engines are mounted immediately ahead of the rotor, with exhaust ducts pointing to left and right, the two free-turbine outputs being geared directly to the rotor. The first development engine ran less than a year ago, but demonstrated its ability to meet the guaranteed output and consumption figures during a 50hr test last autumn. Sikorsky already have several JFTD12s, for rig-running and prototype installation. The industrial variant is the 3,000 h.p. FT12.

REACTION MOTORS *Reaction Motors Inc, A Division of Thiokol Chemical Corp, Denville, NJ.* By most standards, this company's LR99 rocket motor is the most powerful engine ever mounted in an aeroplane. As the ultimate powerplant of the North American Aviation X-15 hypersonic research aircraft, it has been rapidly gaining flight experience throughout the past 12 months, and has now operated at full throttle for 90sec continuously, allowing the aircraft to come close to its design speed of 4,000 m.p.h. The LR99 has a single, fixed chamber, with ceramic lining, fed by turbopump with ammonia and liquid oxygen. Purging of the system is effected by helium, as outlined in our issue for November 25, 1960. Sea-level thrust varies up to 57,000 lb.

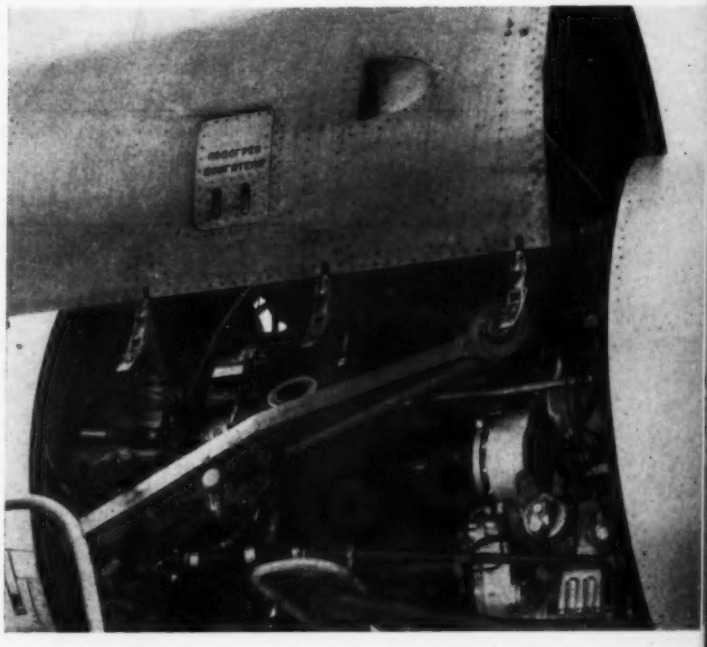
SOLAR *Solar Aircraft Company, San Diego 12, California.* This company's Titan turboshaft is one of the smallest engines ever built for aircraft propulsion. Weighing but 52lb, complete with a large hand-crank for starting, it has flown as the primary powerplant of the Gyrodyne XRON-1 helicopter. An almost identical engine drives the airborne auxiliary powerplant for the Boeing-Vertol HC-1B Chinook transport helicopter and the de Havilland AC-1 Caribou.

USSR

Reliable information on Soviet engines continues to be distressingly sparse, and the temptation to surmise is strong. The only new facts to become available during the past year are the designations "RS7F, 5,950kg" (13,117lb) given for the engines of the "E-66" aircraft, "Type 37V, 4,000kg" (8,818lb) given for the turbojets of the "RV" aircraft, and the remarkable thrust of 13,000kg (28,660lb) given for the "Ty pe D-15" turbojets of the four-engined 103-M and 201-M aircraft. Standard engines with Aeroflot include the RD-3 turbojet, or A M-3M, rated at 19,180lb, the Ivchenko AI-20 turboprop rated at 4,015 e.h.p., the Soloviev TB-2BM turboshaft engine in the Mi-6 helicopter, and the big NK-12M turboprop of the Tu-114, commonly supposed to deliver some 12,000 e.h.p.

Although the AI-20 turboprop appeared accurately drawn in our issue of November 25, 1960 (Il-18 cutaway), the picture below is one of the first to show the actual engine, or any modern Russian engine. It was taken earlier this month by a colleague, who was informed that the overhaul life has recently been raised from 200 to 500hr. As for the remarkable powerplants fitted to the aircraft portrayed last week, and on pages 98-99, the writer will conclude this review with the considered opinion that the Soviet gas-turbine and rocket engineers are level with those of the West.

Ivchenko AI-20 turboprop in Il-18



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DATA FOR REPRESENTATIVE ENGINES

AFTER much deliberation it has been decided to present data on the world's aero engines in the form of these tables, rather than in the form of individual "potted specifications" which have been the rule hitherto. The following explanations are necessary. Unless otherwise stated, all performance is based upon standard-day conditions, and the maximum power is the sea-level static figure. Airflow and pressure-ratio figures are for this condition. It is clearly impossible to adopt a common standard of quoting performance, but most major manufacturers give guaranteed-minimum figures, and these have been used wherever available. It is no easier to tar every engine with the same brush even in such superficially simple matters as giving a figure for its length or weight; but the values quoted are those provided by the manufacturers, and careful inspection shows that some firms are more honest than others in allowing for the external dressing which a bare engine has to wear before it can be put into an airframe. The overhaul life is the maximum reached by the engine; many operators may not yet have attained this life with the same powerplant. The column "Engine configuration" describes the basic geometrical layout; the numbers indicate how many stages there are of fan blading f, axial compression a, centrifugal compression c, turbine stages t, compressor-turbine stages ct, and power-turbine stages pt, and a plus-sign means that the portions so linked rotate together; the piston-engine configurations are simpler, O4, inj signifying four opposed direct-injection cylinders, R18,4 meaning a nine-cylinder radial, geared and supercharged, and 14L being an inverted four-in-line.

TABLE 1: TURBOJETS

DESIGNATION		Engine configuration	Length (in)	Dia. (in)	Wt. (lb)	Air-flow (lb/sec)	Press. ratio	Max. power lb thrust; r.p.m.	Typical cruise power Feet; knots; thrust; s.f.c.; r.p.m.	O'haul life (hr)	Main applications
Manufacturer	Military										
BMW.8026	—	1c, 1t	23.6	14.96	84	—	—	110; 45,000	—	—	Sailplanes
BS.											
Olympus BOL7	Mk 201	5a, 7a, 1t, 1t	126.4	41.75	—	—	—	17,000;	—	—	Avro Vulcan B.2
Olympus BOL21	Mk 300	6a, 7a, 1t, 1t	128	44.5	—	—	—	20,000;	—	—	Avro Vulcan (new mark)
Orpheus BOr.4	Mk 100	7a, 1t	75.5	32.4	900	—	—	4,230;	—	—	Folland Gnat T.1
Orpheus BOr.3	Mk 803	7a, 1t	75.45	32.4	835	84	4.4	5,000; 10,000	—	—	Fiat G.91
Viper ASV.11	Mk 22-1	7a, 1t	63.7	24.55	549	42	—	2,500; 13,800	20,000; 500; 1,190; 1.25; 12,700	—	MB-326, PD-808
Viper ASV.20	—	8a, 1t	103.5	32	593	52.8	5.09	3,000; 13,800	—	—	D.H.125 Jet Dragon
Continental											
CJ69-1025	J69-25	1c, 1t	50	24.9	364	19.8	—	1,025; 21,730	45,000; 600; 205; 1.24; 20,000	—	—
——	J69-29	1a + 1c, 1t	46.25	22.36	335	28.3	—	1,700; 22,000	45,000; 600; 330; 1.315; 20,130	—	Targets and drones
CJ69-1400	—	1a + 1c, 1t	44.8	22.3	370	—	5.1	1,400; 21,000	25,000; 400; 403; 1.128; 19,800	—	Cessna 407
D.H. Gyron Junior											
DGJ.2	Mk 101	8a, 2t	102.9	34.4	—	—	—	7,100;	—	—	Blackburn Buccaneer S.1
DGJ.10	—	8a, 2t, ab	191	32.3	—	—	—	14,000*;	—	—	Bristol T.188
Fiat 4004.001	—	1c, 1t	37.5	22.44	198	10.4	4	618; 25,000	—	—	—
G.E. CJ610-1	—	8a, 2t	41	17.7	355	44	—	2,850; 16,500	—	—	Aero Jet Commander 1121
CJ805-3	—	17a, 3t	109.56	31.6	2,800	167.9	13	11,200; 7,684	—	1,000	CV-880
CJ805-3B	—	17a, 3t	109.56	31.6	2,815	167.9	13	11,650; 7,460	25,000; 525; 4,300; 0.97; 7,460	1,000	CV-880-M
——	J79-2	17a, 3t, ab	207.96	38.31	3,620	167.9	13	16,250*; 7,460	—	—	NAA A3J-1, McDonnell F4H-1
——	J79-5B	17a, 3t, ab	202.17	38	3,635	167.9	13	15,600*; 7,460	—	—	Convair B-58A
——	J79-11A	17a, 3t, ab	207.96	38.31	3,485	167.9	13	15,800*; 7,460	—	—	Lockheed F-104G
——	J85-5	8a, 2t, ab	108.8	20.2	538	42.5	7	3,850*; 16,500	35,000; 585; 1,180; 1.54; 16,500	—	T-38, N-156F and Q-4B
——	J85-7	8a, 2t	39.3	17.5	326.5	42.5	6.5	2,450;	35,000; 585; 580; 1.17; 14,850	—	GAM-72 Green Quail
——	J93-5	—	—	—	—	300+	8	30,000;	80,000; 1,800;	—	North American B-70 Valkyrie
Nippon J-3-3	—	8a, 1t	72.85	28.35	815	—	—	2,645;	—	—	Fuji T1B
P & WA. JT3C-2	J57-43WB	9a, 7a, 1t, 2t	167.33	38.88	3,840	180	12.5	13,750; 8,000	—	—	Boeing B-52G
JT3C-6	—	9a, 7a, 1t, 2t	138.64	38.88	4,234	180	12.5	13,500; 8,000	20,000; 565; 4,850; 0.963	1,800	Boeing 707-120, DC-8-10
JT3C-7	—	9a, 7a, 1t, 2t	136.77	38.88	3,495	180	12.5	12,000; 8,000	20,000; 565; 5,350; 0.957;	1,200	Boeing 707-120, 720, DC-8-10
JT3C-12	—	9a, 7a, 1t, 2t	138	38.88	3,550	180	12.5	13,000; 8,000	—	—	—
JT3C-26	J57-20	9a, 7a, 1t, 2t, ab	—	38.88	4,750	180	12.5	18,000*;	—	—	Chance Vought F8U-2
JT4A-9	—	8a, 7a, 1t, 2t	144.1	43	5,050	300	12	16,800; 8,000	—	1,400	DC-8-20, DC-8-30, 707-320
JT4A-11	—	8a, 7a, 1t, 2t	144.1	43	5,100	300	12	17,500; 8,000	—	—	DC-8-30, Boeing 707-320
JT4A-29	J75-19W	8a, 7a, 1t, 2t, ab	259.3	43	5,960	300	12	26,500*;	—	—	Republic F-105
JT8A-	J52-6	—	—	—	—	—	—	8,500;	—	—	Grumman A2F, Douglas A4D-
JT11	—	—	—	—	—	—	8	23,000;	—	—	—
JT12-6	—	9a, 2t	74.2	21.9	436	—	—	3,000;	—	—	Lockheed Jet Star, C-140, T-1C CL-41, and NAA T-39
JT12-21	J60-	9a, 2t, ab	126	21.9	651	—	—	4,025*;	35,000; 1,180; 3,650;	—	—
R-R.											
Avon RA.24R	Mk 210	15a, 2t, ab	—	—	—	—	—	14,430*;	—	—	English Electric Lightning
Avon RA.29/1	—	16a, 3t	126	39	3,343	173	9.1	10,250; 8,050	25,000; 425; 3,400; 0.932;	2,900	D.H. Comet 4, 4B, 4C
Avon RA.29/6	—	17a, 3t	134	39	3,491	185	10.3	12,725; 8,150	25,000; 425; 4,680; 0.918;	1,200	Sud Caravelle 6
Avon RB.146	Mk 300	16a, 2t, ab	—	—	—	—	—	16,600*;	—	—	—
SNECMA Atar 9C	—	9a, 2t, ab	246	40	2,997	149.9	5.5	13,228†; 8,400	—	—	Dassault Mirage III
Turbomeca											
Marbore 2	—	2c, 1t	37.2	14.4	356	—	3.85	880; 22,600	9,900; 290; 353; 1.365;	—	Potez-Fouga Magister, MS. Paris, HS Saeta
Marbore 6	—	2c, 1t	37.2	14.4	363	—	3.84	1,058; 21,500	9,900; 470; 550; 1.41;	—	MS Paris 2 and 3, Potez-Heinkel CM.191

* *With reheat.* † *With reheat; this engine delivers 14,110lb at flight Mach numbers greater than 1.4.*

TABLE 2: TURBOFANS

DESIGNATION		Engine configuration	By-pass ratio	Length (in)	Dia. (in)	Wt. (lb)	Airflow (lb/sec)		Press. ratio	Max. power lb thrust; r.p.m.	Typical cruise power Ft; knots; thrust; s.f.c.	O'haul life (hr)	Main applications
Manufacturer	Military						Total	Hot					
BS.53 Pegasus	Mk 100	2f, 7a, 1t, 3t	—	—	46.5	—	—	—	—	—	—	—	Hawker P.1127
BS.58	—	2f, 7a, 1t, 3t	—	123	46.5	2,600	—	—	—	14,500;	36,000; 500; 3,750; 0.80	—	—
BS.75	—	3f, 10a, 2t, 2t	1.6	92.3	35.5	1,525	196	72	13	7,550; 8,900	25,000; 460; 2,530; 0.783	—	BAC-107
GE.CF700-2B	—	8a, 2t, 1f	1.9	65	34	640	130	44	7	4,200; 16,500	—	—	—
GE.CJ805-23A	—	17a, 3t, 1f	1.56	130.9	53	3,730	417.9	167.9	13	16,100; 7,680	25,000; 525; 5,100; 0.83	—	CV-990
P & WA.JT3D-1	—	2f+6a, 7a, 1t, 3t	1.4	136.32	53	4,065	480	200	12.5	17,000; 8,000	30,000; 525; 3,150; 0.8	1,000	Boeing 707-120B, 720B, DC-8-50
P & WA.JT3D-2	TF33-3	2f+6a, 7a, 1t, 3t	1.4	136.5	53	3,900	480	200	12.5	17,000; 8,000	—	—	Boeing B-52H, C-135B
P & WA.JT3D-3, 4	TF33-5	2f+6a, 7a, 1t, 3t	1.4	—	53	4,170	480	200	12.5	18,000; 8,000	30,000; 525; 3,500; 0.785	—	—
P & WA.JT3D-8A	TF33	2f+7a, 7a, 1t, 3t	—	—	53	4,490	—	—	—	21,000;	30,000; 525; 3,900; 0.775	—	Lockheed C-141
P & WA.JT3D-14	TF33	3f+6a, 7a, 1t, 3t	—	—	—	—	—	—	—	24,000;	35,000; 585; 4,680; 0.75	—	—
P & WA.JT8D-1	—	2f+4a, 7a, 1t, 3t	1.1	122.5	44.5	2,994	305	146	15.5	14,000; 11,000	25,000; 505; 3,500; 0.82	—	Boeing 727
R-R.													
Conway RCo.12	—	7f, 9a, 1t, 2t	0.3	136	42	4,544	281	216	14.1	17,500; 9,980	35,000; 475; 4,800; 0.9	1,800	Boeing 707-420, DC-8-40
Conway RCo.15B	—	7f, 9a, 1t, 2t	0.3	136	42	4,584	295	227	14.3	18,500; 9,895	35,000; 475; 5,200; 0.862	—	—
Conway RCo.42/1	—	4f+3a, 9a, 1t, 2t	0.6	—	45	5,001	363	227	14.6	20,250;	35,000; 475; 5,430; 0.84	—	Vickers VC10
Conway RCo.42/3	—	4f+3a, 9a, 1t, 2t	0.6	—	45	5,100	363	227	14.6	21,800;	35,000; 475; 5,570; 0.82	—	Vickers Super VC 10
Spey 1	—	4f, 12a, 2t, 2t	1.02	110	37	2,200	202	100	16.75	9,850; 12,490	32,000; 508; 3,150; 0.787	—	D.H. Trident, BAC-111, Caravelle Junior
SNECMA JTF10A-1	TF30*	—	1.5	128.4	38	2,116	230	92	—	8,267;	29,500; 570; 2,701; 0.81	—	Mirage 5 project
SNECMA JTF10A-2	—	—	1.5	—	38	2,315	230	92	—	9,480;	—	—	Airliners

* *Abandoned in US, through lack of Navy money.*

TABLE 3: TURBOPROPS

DESIGNATION		Engine configuration	Length (in)	Dia. (in)	Weight (lb)	Air-flow (lb/sec.)	Press. ratio	Maximum power s.h.p.; e.h.p.; r.p.m.	Typical cruise power Ft.; knots; e.h.p.; s.f.c.	O'haul life (hr)	Main applications
Manufacturer	Military										
Rolls-Royce 250-B2	T63-1	7a+1c, 1ct, 2pt	38.9	15.8	147	3	6.2	250;	6,000; 0·200; 206; 0.72	—	—
Allison 501-D13	—	14a, 4t	145.2	27	1,750	32.5	9.25	3,460; 3,740; 13,820	25,000; 360; 1,905; 0.467	1,800	Lockheed Electra
—	T56-1A	14a, 4t	145.1	27.5	1,645	32.5	9.25	3,460; 3,740; 13,820	—	—	Lockheed C-130A
—	T56-10W	14a, 4t	—	—	—	32.5	—	4,585; 13,820	—	—	Lockheed P3V-1 Orion
Boeing 520-4	Yes	1c, 1ct, 1pt	68.7	25.5	325	5.3	6.4	475	—	—	—
Boeing 520-8	Yes	1c, 1ct, 1pt	68.7	25.5	275	5.3	6.4	550	—	—	—
Bristol Proteus 765	—	12a+1c, 2ct, 2pt	110.6	40.1	2,900	44.9	7.2	3,915; 4,400; 11,700	25,000; 340; 2,675; 0.501	1,350	Bristol Britannia
P & WA PT6A-3	T74-	3a+1c, 1ct, 1pt	61.5	19	250	5	6	466; 500; 33,000	—	—	—
H. Gnome P.1200	—	10a, 2ct, 1pt	79.3	16*	595	12.4	8.3	1,150; 26,260	0; 0; 805; 0.728	—	—
Lycoming T53	T64-8	14a, 2ct, 2pt	113	24†	1,136	24.5	12.6	2,850; ; 15,590	20,000; 370; 1,724; 0.493	—	Grumman Gulfstream
Lycoming T53	T53-3	5a+1c, 1ct, 1pt	58.4	23	530	10.7	6	960; 1,005; 25,240	—	—	Grumman AO-1 Mohawk
Lycoming T53	T53-7	5a+1c, 1ct, 1pt	58.4	23	522	10.7	6	1,100; 1,150; 26,000	—	—	—
Pratt & Whitney PT5	T55-	7a+1c, 1ct, 2pt	62.2	24.76	795	—	6.3	2,535;	—	—	—
Rolls-Royce Dart RDa.7 Mk. 514	—	10a, 3t	95.5	36	1,820	33.5	7	3,230; 3,500; 12,500	—	800	Canadair CL-66; CV-540
Rolls-Royce Dart RDa.6 Mk. 506	—	2c, 2t	98	38	,106	20.5	5.4	1,600; 1,660; 14,500	20,000; 300; 985; 0.634	3,100	Viscount, F-27, Avro 748-1
Rolls-Royce Dart RDa.7 Mk. 510	—	2c, 3t	98	38	1,207	23.5	5.6	1,910; 2,020; 15,000	20,000; 300; 1,315; 0.573	3,000	Viscount, F-27, Herald, Argosy, Avro 748-2, Gulfstream
Rolls-Royce Dart RDa.10/1 Mk. 511	—	2c, 3t	98	38	1,377	27	6.35	2,750; 3,030; 15,000	20,000; 300; 1,612; 0.556	—	Namco YS-11
Rolls-Royce Tyne RTy.1	—	6a, 9a, 1t, 3t	—	—	2,275	46.5	13.5	4,500; 4,785; 15,250	25,000; 370; 2,685; 0.405	400	Vickers Vanguard 951
Rolls-Royce Tyne RTy.11	—	6a, 9a, 1t, 3t	—	—	2,275	46.5	13.5	; 5,325; 15,250	25,000; 370; 3,180; 0.389	—	Vickers Vanguard 952
Rolls-Royce Tyne RTy.12	—	6a, 9a, 1t, 3t	—	—	2,177	46.5	13.5	; 5,500; 13,250	30,000; 320; 2,695; 0.391	—	CL-44, Short Belfast
Rolls-Royce Tyne RTy.20	Yes	6a, 9a, 1t, 3t	—	—	2,205	46.5	13.5	; 5,855; 15,250	30,000; 320; 2,786; 0.388	—	—
Rolls-Royce Tyne RTy.21	Yes	6a, 9a, 1t, 3t	—	—	2,279	46.5	13.5	; 6,180;	30,000; 320; 2,803; 0.389	—	Breguet 1150 Atlantic
Rolls-Royce Tyne RTy.22	Yes	6a, 9a, 1t, 3t	—	—	2,279	46.5	13.5	; 7,075;	30,000; 320; 3,005; 0.383	—	Transall C-160
Rolls-Royce TP.90	—	1c, 1t	49.6	27.6	235§	—	—	100;	—	—	—
Turbomeca Astazou 2	—	1a+1c, 3t	68.4	18	314	—	5.81	530; 562; 43,000	—	750	Sipa 272, Marquis, Potez 840
Turbomeca Astazou 2 Spec.	—	1a+1c, 3t	68.4	18	314	—	—	562; 595; 43,500	20,000; 270; 402; 0.492	750	—
Turbomeca Bastan 4	—	1a+1c, 3t	60	26.2	837	—	5.45	917; 986; 33,500	9,900; 350; 795; 0.58	750	MH.260/2, Dassault Spirale 3
Turbomeca Turmo 3D	—	1a+1c, 2ct, 1pt	75.6	37	694	—	5.5	1,169; 1,208; 33,500	0; 0; 848; 0.737	—	Breguet 941, 942, 945

**Height, 31.55in; † height, 46 in; ‡ cowled powerplant; § including propeller.*

TABLE 4: TURBOSHAFTS

DESIGNATION		Engine configuration	Length (in)	Dia. (in)	Weight (lb)	Air-flow (lb/sec)	Press ratio	Max. power s.h.p.; r.p.m.; minutes time	Output r.p.m.	Rated or 1hr power Ft; knots; s.h.p.; s.f.c.; r.p.m.	Main applications and related units
Manufacturer	Military										
Aerojet-General Research 331	—	2c, 3t	41.5	16.4	200	4.39	—	440; 39,000;	—	—	—
Allison 250-C2	YT63-	7a + 1c, 1ct, 2pt	34.6	15.8	128	3	6.2	250;	—	0; 0; 191; 0.76;	Bell HUL-1M
Blackburn Nimbus	BN-1	2a + 1c, 2ct, 1pt	62.66	20.1	390	11	6.5	1,900; 35,000;	—	0; 0; 815; 0.718; 34,000	Westland Scout
BMW 6012	—	1ct, 1t	24.5	15	100	—	—	88.8; 45,000;	3,000-8,000	—	—
Boeing 520-2	YT60-2	1c, 1ct, 1pt	57.5	25.2	315	5.3	6.4	430; 24,800	6,200	0; 0; 375; 0.78;	—
Boeing 520-6	—	1c, 1ct, 1pt	57.5	25.2	250	5.3	6.4	550;	6,000	0; 0; 500; 0.67;	—
P & WA PT63-3	YT74-2	3a+1c, 1ct, 1pt	58	19	225	5	6	500; 33,000	6,000	0; 0; 400; 0.75;	—
Continental T72-2	T72-2	1a+1c, 2ct, 1pt	42.48	19.38	210	—	—	500; 42,000; 5	5,976	6,000; 0; 265; 0.78; 41,000	—
D.H. Gnome H.1200	DGe.2	10a, 2ct, 1pt	54.8	16	320	12.4	8.3	1,350; 26,750; 2½	19,500	10,000; 100; 950; 0.602; 25,920	Whirlwind, Agustas and B-V 107-II
Coupled Gnome	—	2 × Gnome	78	40	1,034	24.8	8.3	—	2,915	0; 0; 2,500†; 0.624; 26,260	Westland Wessex 2
G.E. CT58-100-2	—	10a, 2ct, 1pt	55	16	295	12.4	8.3	1,050; 26,260; 5	19,500	10,000; 0; 785; 0.63; 25,920	B-V 107-II, S-61L and S-62
—	T58-8B	10a, 2ct, 1pt	55	16	295	12.4	8.3	1,250; 26,260; 5	19,500	20,000; 0; 680; 0.585; 25,920	HRB-1, HU2K, HSS-2
—	T64-2	14a, 2ct, 2pt	91	25	864	24.5	12.6	2,850; 13,600; 10	5,200	15,000; 100; 1,490; 0.504; 13,600	—
—	T64-6	14a, 2ct, 2pt	83	24	713	24.5	12.6	2,850; 13,600; 10	13,600	15,000; 100; 1,575; 0.497; 13,600	—
Lycoming T53	T53-1	5a + 1c, 1ct, 1pt	47.61	23	484	10.7	6	860; 25,240;	6,680	—	Bell HU-1, Kaman H-43B
—	T53-9	5a + 1c, 1ct, 1pt	47.61	23	485	10.7	6	1,100; 26,000;	—	—	Bell 204, Bell HU-1D
—	T55-5	7a + 1c, 1ct, 2pt	45.21	24.76	570	—	6.3	2,280; 14,550;	—	0; 0; 1,920; 0.595; 14,000	Boeing-Vertol HC-1B
Napier Gazelle	NGa.13	11a, 2ct, 1pt	70*	33.5	865	16	5.9		3,000	0; 0; 1,450; 0.703; 19,500	Westland Wessex 1
Rolls-Royce Gazelle 512	—	11a, 2ct, 1pt	71.5	31	675	16.8	6.25	1,750; 20,300	18,000	6,000; 0; 1,135; 0.67; 19,700	—
Solar Titan	YT62	1c, 1t	25*	12.5	52	1.4	3.2	65; 56,700; cont	4,045	0; 0; 65; 1.1; 56,700	Gyrodyne XRON-1
Turb. Artouste 2C	—	1c, 2t	56.4	20.4	314	—	—	473; 34,000; cont	6,000	0; 0; 345; 1.02; 32,000	Sud 3130 Alouette 2
Artouste 3C	—	1a + 1c, 3t	68.4	20.4	291	—	—	543; 33,500; cont	6,000	3,280; 0; 405; 0.81	Sud 3160 Alouette 3
Turmo 3C	—	1a + 1c, 2ct, 1pt	66.2	25	455	—	5.5	1,200; 33,500;	5,700	6,560; 130; 1,000; 0.614	Sud 3210 Frelon

** Height, engine is mounted approximately vertically; † limited to 1,550 s.h.p. by aircraft transmission*

TABLE 5: TURBOCOMPRESSORS

DESIGNATION	Engine configuration	Length (in)	Dia. (in)	Weight (lb)	Air-flow (lb/sec)	Press ratio	Max. delivery lb/sec; lb/sq in; r.p.m.	Gas h.p.	Max. continuous rating lb/sec; lb/sq in; g.h.p.; r.p.m.	Main applications
Blackburn Cumulus	2a + 1c, 2t	34.4	17.7	210	7.95	3.8	2.38; 56.5; 35,000	250	2.6; 41.9; 230; 35,000	
Palouste 505	1c, 2t, bleed	52.2	34.8	205	7.7	3.81	2.6; 38.5; 34,000	260	—	—
Fiat 4700	1c, 1ct, 1pt, 1c	51.2*	24.1	335	10.4	4	7.72; 48; 25,000	610	; ; 500;	Fiat 7002
Turbomeca Palouste 4	1c, 2t, bleed	52.8	34.8	205	—	—	2.51; 41;	—	2.46; 39;	SO.1220 Djinn

** Height*

TABLE 6: PISTON ENGINES

DESIGNATION	Configuration	Dimensions (inches)			Weight (lb)	Bore (in)	Stroke (in)	Capacity (cu in)	Fuel grade	Maximum power h.p.; r.p.m.	Typical cruise power Ft; h.p.; r.p.m.; gal/hr	Main applications
		Length	Width	Height								
Agusta GA.40	O2	24.1	30.9	17.71	123.46	3.937	3.74	91.1	80/87	41; 2,700	0; 20; 2,000; 1.45	—
GA.70	O4	29.9	29.52	17.71	176.4	3.622	3.4	140.3	80/87	72; 2,700	0; 54; 2,500; 3.9	—
GA.70V	O4, vert	18.5	21.26	18.5	176.4	3.622	3.4	140.3	80/87	82; 3,300	0; 64; 3,000; 4.65	—
A. 140V	O4, vert	22.83	31.49	27.17	255.8	4.51	3.49	222.93	91	139; 3,200	5,000; 107; 3,000;	—
Alvis Leonides 531	R9, g, s	54.4	41.5	41.5	860	4.8	4.8	783	100/130	650; 3,200	10,250; 360; 2,600; 25	Scottish Aviation Twin Pioneer 3
Avdna 4CO2	O4	—	—	—	133	3.031	2.52	72.62	80	30.7; 3,000	—	Rollason Turbulent
Continental A65	O4	30.4	31.5	20.3	170	3.875	3.625	171	73	65; 2,300	0; 43; 2,000; 3.1	—
O200A	O4	28.53	31.56	23.18	190	4.0625	3.875	201	80/87	100; 2,750	0; 65; 2,500;	—
O300A	O6	39.75	31.5	23.25	268	4.0625	3.875	301	80/87	145; 2,700	0; 103; 2,400;	—
10470D	O6, inj	43.31	33.56	19.75	426	5	4	471	100/115	260; 2,625	5,000; 188; 2,300;	—
Lycoming IO360	O4, inj	32.81	33.37	22.47	291	5.125	4.375	360	91/96	180; 2,700	7,500; 135; 2,450;	Mousquetaire, Rubis, Sancy
TVO435-A1A	O6, vert, turb	34.73	33.58	36.51	468	4.875	3.875	435	100/130	260; 3,200	—	—
GO480-B1A6	O6, g	39.84	33.12	28.02	432	5.125	3.875	480	80/87	270; 3,400	6,000; 195; 2,750;	—
IO540	O6, inj	38.62	34.25	19.6	437	5.125	4.375	540	100/130	290; 2,575	6,000; 220; 2,350;	—
IGSO540-B1A	O6, inj, g, s	48.5	34.25	20.29	532	5.125	4.375	540	100/130	380; 3,400*	13,000; 270; 2,750;	—
VO540-C1A	O6, vert	34.73	34.7	24.58	439	5.125	4.375	540	100/130	305; 3,200	9,500; 240; 3,200;	—
M-332	14L	43.4	16.7	23.9	225	4.13	4.53	242.78	72	140; 2,700	1,000; 95; 2,400; 5.61	—
M-337	16L, s (opt.)	55.5	18.4	24.7	313	4.13	4.53	364.25	72	210; 2,750	5,000; 140; 2,400;	Morava L.200A
Motor Alfa 4	R8	45.27	23.4	23.4	320	4.133	3.071	329.52	—	220; 2,800	—	—
Alfa 5	R8	34.25	23.4	23.4	268	4.133	3.071	329.52	—	320; 4,000	—	Targets and drones
Porsche 678/4	O4, g	28	32	25.4	247	3.25	2.91	96.5	72	75; 4,600	0; 60; 4,270; 3.9	—
Potez 4D-34	14L, s	46.8	20.5	27.6	408	—	—	—	100/130	260; 2,550	0; 200; 2,400;	Nord 3202, 3400
4E-20	O4	30.7	30.1	23.9	207	4.33	3.543	209	80/87	105; 2,750	0; 75; 2,450;	—

** At up to 12,000ft.*

A possible long-range intercepter

SEEN AT TUSHINO

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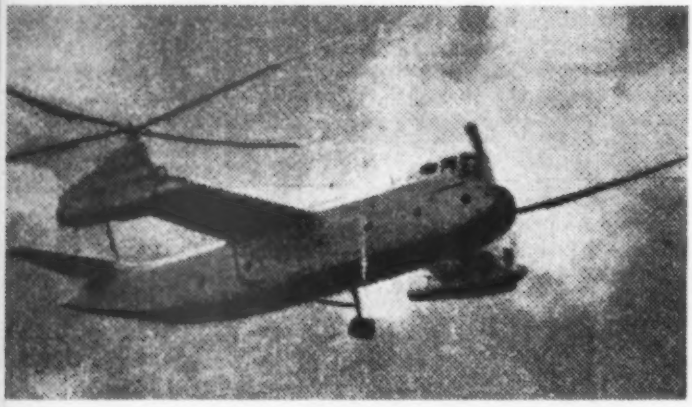
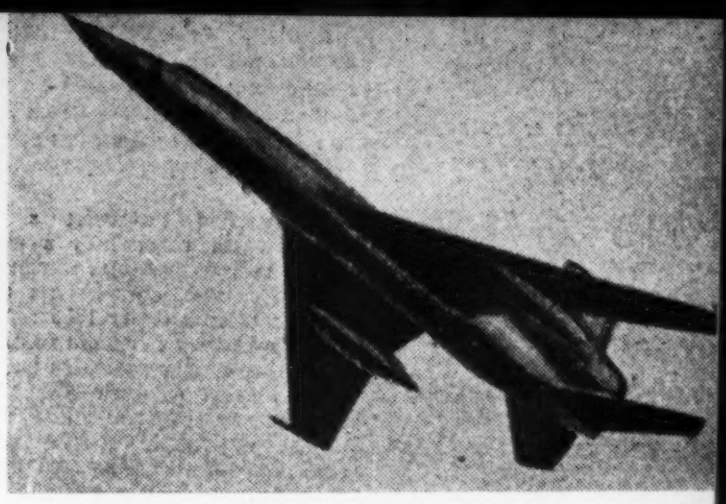


Above and below, Kamov's turbine-powered "Vintokrilya" compound helicopter—Russia's counterpart of the Westland Rotodyne

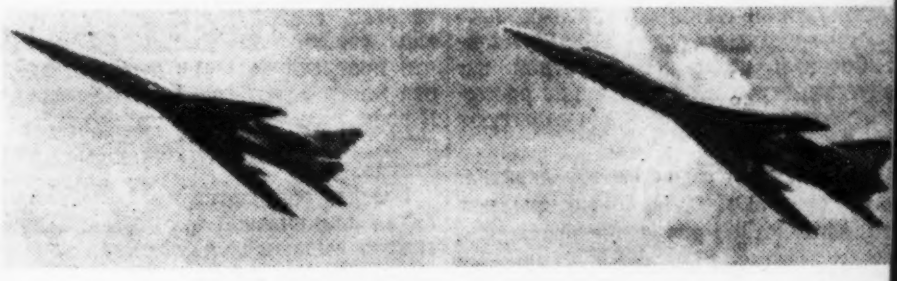
Above and below, possible long-range intercepter version of "Backfin"

A fly-past of jet-propelled flying-boats of the Russian Navy

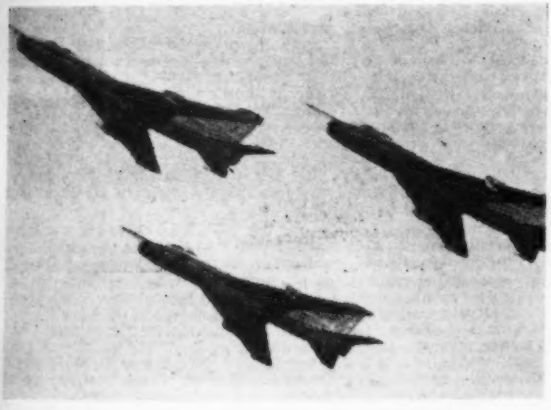
A probable Sukhoi twin-jet fighter



Right and below, views of the new bomber with rear-mounted jets and Tu-104-type undercarriage fairings

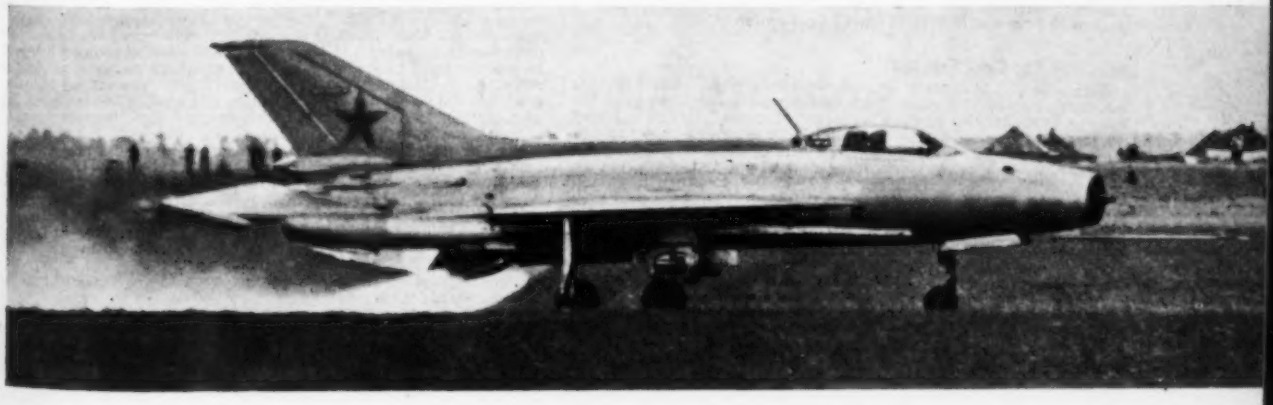


Supersonic fighters—apparently "Fitters"



New view of the "Bounder" bomber escorted by Sukhoi fighters

Rocket-assisted take-off by a Sukhoi single-jet fighter. This is by far the most detailed picture of a modern Russian fighter yet seen



AIR COMMERCE

On July 14 United Air Lines introduced Sud Caravelle 6Rs on its services between New York and Chicago. Twenty are to be delivered to UAL before the end of next January. This is the first time British jet engines (Rolls-Royce Avon 532Rs) have entered service with a US airline. TWA also may buy Avon Caravelles

ATLB PUBLIC MEETING 21 (Continued)

MR A. H. MILWARD, chief executive of BEA, next gave evidence in support of BEA's general objections to the applications. He said that competition was a subject about which there was a great deal of confusion, which was being exploited by the applicants. There was no business so competitive as European air transport. BEA was by no means a "supine and complacent monopoly." Competition was increasing and had not been reduced by pool agreements. Traffic, particularly from the American market, was down this year; whereas capacity had gone up by 35 per cent, traffic had increased by only 15-17 per cent.

He referred to the proposed 2d per mile fares to be introduced on the Glasgow route. BEA admittedly had a virtual monopoly of domestic routes, but this had not made them complacent. In Europe BEA were having to meet competition from other operators with the most modern jet equipment. On the route to Rome there were 17 operators besides BEA, operating Boeing 707s, Comets, Caravelles, Electras, Britannias, Super Constellations and DC-6s. About 12,000 out of 90,000 passengers on this route were carried by fifth freedom operators, and 42 per cent on the Frankfurt route.

Asked to comment on pools in general, Mr Milward said that they did not lead to complacency or lack of incentive. Each airline retained its own selling organization intact and was always trying to get a larger share of the pool. The division of traffic under a pooling agreement might be changed if one partner could show that the other was unproductive. On the subject of the traffic areas served by Gatwick and Heathrow, Mr Milward said that the competitors were claiming to use different airports, but these catered for the same area as Heathrow. A Ministry letter about the possible transfer of BEA services from Heathrow to Gatwick had made this clear.

Asked to review BEA's operations and financial position and estimated traffic growth, Mr Milward said he considered that the applications offered a serious threat to an enterprise which had been built up into a profitable business. They would cause duplication and diversion. A series of charts introduced by BEA would illustrate his evidence. Only four operators in the United States, where a very different domestic traffic pattern materially affected the situation, exceeded the BEA uplift of 4m passengers annually. The average journey length and average fare on BEA services were well below world averages for both international and domestic services. The BEA traffic was markedly seasonal and the variations between August and February showed ratios varying between 8.2:1, on the London - Jersey route, and 1.6:1, on the London - Zürich route. This led to under-employment of staff in the winter. Passenger load factors since 1956-57 had varied between a peak of 72.8 per cent in 1957-58 and 62.5 per cent in 1958-59.

BEA And The Peak Problem

Reference had been made to peak weekends, when seats were not available, said Mr Milward. Such peaks were essential to keep the average at a desirable level. They occurred in all forms of industry. As far as air transport was concerned BEA were not alone; it was impossible to book on the car ferry services of Silver City during the holiday peak months and Cunard Eagle's service to Italy was also fully booked. BEA traffic growth between 1950 and 1960 had been well above world average, which showed that BEA had not been held back by monopoly or by pooling agreements. Between 1949 and 1959 BEA had increased their share of the total UK/Continent traffic from 44 per cent to 56 per cent, despite the fact that there had been 20 carriers in 1959 compared with 12 in 1949. Further charts showed BEA's success since the first seven formative years, with profits since 1955.

Of the 1961-62 situation, Mr Milward said it would be a difficult year. This state of affairs was general. Traffic was falling behind capacity everywhere, particularly the traffic ex-US. BEA carried dollar traffic to the value of $10m annually, but this was falling off as a result of the President of the United States urging Americans to spend less money abroad. Mr Milward referred to another chart which showed that a drop of 5 points in BEA's load factor would have carried every one of the profitable years into the red. This was very important for preparing forward estimates; an error of one point would mean a difference of £750,000. Mr Milward said that another chart would show how the independents had cleverly increased their percentage of the total air traffic to the Continent by operating routes complementary, but not parallel, to those of BEA and by operating inclusive tours, which are not considered by most foreign governments to affect bilateral agreements. He thought that this was the direction in which the independents should concentrate their development, and complimented Tradair on being the only applicant to come before the Board with a constructive proposal which did not seek to take traffic away from BEA.

Mr Milward said that the applications would, if granted, result in the diversion of traffic to the value of £12.9m from BEA to independents in the year 1964-65. The estimated diversion was based on 80-seat aircraft operating at a load factor of 57 per cent.

Independent Claim "Balderdash"

Asked whether he thought that the applicants had really asked for all they wanted, or would they want more later, Mr Milward said that this was a very serious question. As no one had proved BEA incompetent, the applicants were saying that they had made a bid for a small share of a developing market. Mr Milward thought that was "balderdash" and a subterfuge not creditable to the shipping lines. He was sure that the shareholders of the shipping companies behind the applications would not be content with small shares of a number of routes. They would want more and more.

On the subject of domestic services, Mr Milward said that these were a special problem. Only the best of them had been sought by the applicants and there was also competition from the railways. Charts showed the losses sustained in the past and the dramatic increase in traffic on trunk domestic routes in 1960. After spending £3m on the development of domestic services in the years 1947-58, BEA were nearing a breakthrough and now the independents wanted to participate. By operating frequent services, BEA had built up traffic and improved economy of operation on busy domestic routes: they were operating 10 services daily between London and Manchester. Mr Milward thought it would be grossly stupid to prejudice the future of BEA's domestic services at this stage by draining traffic away from them. The tax on kerosine cost £150,000 a year on domestic routes, and landing fees absorbed the total fares of 18 passengers on each Vanguard flight between London and Manchester.

Mr Milward then dealt with capital expenditure and fleet commitments. He said that the exercise of BEA's option to buy 12 additional Tridents in 1966-67 would depend on the outcome of the applications. Since 1948 BEA had spent £80m on British aircraft and was committed to spending a further £50m between now and 1965.

BEA had other substantial capital commitments; they had £10m invested in the maintenance base at Heathrow, and were going to spend £4½m on a new electronic reservations system.

Summing up BEA's reasons for objecting to the applications, Mr Milward listed four arguments:

(1) The European air transport business was highly competitive already, and the operations of the independents would not benefit the public; (2) BEA's economic balance was very delicate; they were at present making profits, but almost every other airline in the world was

CONTINUED here, in summarized form, are the hearings before the Air Transport Licensing Board relating to the 70-odd applications for European routes applied for mainly by British United Airways and Cunard Eagle. So far, ten days have been devoted to hearings, with a prospect of another eight to come. The hundreds of thousands of words already spoken have outstripped our available space, and many have been spoken since the date to which this summary takes us. However, we have thought it right to sacrifice some topicality in order to maintain a reasonably complete record of these important hearings.

losing money; (3) Granting of the applications would mean more than the division of British effort—it might lead to a reduction in the total share of the traffic carried by British airlines: domestic routes were just beginning to break even and interference with BEA's plans would impede their further healthy development; (4) A dangerous situation would result from slowing down or restricting BEA's growth.

Asked to comment on the problem of fares, Mr Milward said that it was "hellish dark and certainly smelled of cheese." Mr Wyatt of BUA thought that fares should go up and Mr Laker of BUA wanted to bring them down. BEA's revenue rate per mile was 6.4d; BOAC's, on longer stages, with fewer landings and proportionally less ground handling, 6.2d; BEA's average rate for domestic routes was 5.3d—including 4d on domestic trunk routes; and the rate in America, with all the advantages of favourable operating conditions, was 5.1d per mile.

Concluding, Mr Milward said that it was an unfortunate British habit to dig up young and tender plants to examine their roots; he could almost hear the Gardiner's fork digging around BEA's routes.

Beginning his cross-examination of Mr Milward, Mr Gerald Gardiner, counsel for BUA, said that Mr Milward had made an eloquent and moving speech against the Act. Did he think the Act was a mistake? Mr Milward replied that it was for the Board to decide how the Act should be applied, but his case was that all the applications should be turned down. He did not agree that the Board would not be properly applying the Act if BEA retained its monopoly.

Asked to estimate the average percentage of fifth freedom traffic on European routes, Mr Milward said this would be about eight per cent. Mr Gardiner asked whether Mr Milward would agree that the UK generated seven-eighths of the traffic to the Continent. Mr Milward did not agree; he said that the highest percentages generated by the UK were 61-67 per cent—depending on the season—to Switzerland, about 79 per cent to Cologne and about 72 per cent of the summer traffic to Milan. The overall average would be about 60 per cent British-generated and 40 per cent generated elsewhere.

With reference to a BEA chart showing the estimated diversion of traffic if the applications were all granted, Mr Gardiner asked for confirmation that this was based on 80-seater aircraft (BUA's One-Elevens would be only 65-seaters) and on the assumption that all traffic carried by the independents would be diverted from BEA, no new traffic being generated by the independents. Mr Milward agreed that the chart was based on these assumptions and pointed out that BUA would not be using BAC One-Elevens initially but Viscounts and Britannias. The capacities of these two aircraft might average 80 seats.

Referring to the effects of bilateral agreements, Mr Gardiner suggested that it would be reasonable to argue that all British passengers to Madeira should be carried by British airlines and Mr Milward said he was all in favour of a general loosening of bilateral agreements, but these were made by governments. When Mr Gardiner continued to develop this line of questioning, referring to pooling, Mr Milward said he felt he ought not to talk about pools; he would say, however, that he did not like pools but bilateral agreements made them necessary.

BEA's Competition

Mr Milward was next cross-examined by Mr Ashton Hill, for Cunard Eagle. Questioned about competition on European routes and suggestions that the only real competition came from fifth freedom operators, Mr Milward agreed that the only competition on the Malta route came from the low-frequency services of Skyways, but said that the general competition in Europe was keen although it might be insignificant on certain routes. Mr Ashton Hill suggested that reserve aircraft might be utilized to deal with peak traffic and Mr Milward agreed, provided that there were reserves available. He agreed that the lack of available capacity on the Cunard Eagle route serving Pisa was due to frequency and capacity restrictions.

When Mr Ashton Hill referred to certain figures for passengers carried and capacities quoted in document BEA.1, and congratulated BEA on apparently achieving load factors of more than 100 per cent—presumably by carrying passengers in the wings—Mr Milward said that, much as BEA might like to do so, they were not allowed by the ARB to carry passengers in this way; he regretted that the figures seemed to have been transposed. With reference to Mr Milward's remarks about digging around the roots of BEA, Mr Ashton Hill said that Cunard Eagle were only asking for a little pruning to be done. Mr Milward replied that some trees should not be pruned.

Mr Ashton Hill suggested that BEA statistics for the year 1958-59 showed major traffic increases on the routes serving holiday resorts, that the BEA chart of percentages of total passenger traffic between the UK and the Continent carried by BEA, foreign operators and the independents included, in the case of the latter, vehicle ferry and inclusive tour charters; the proportion of passengers carried by the independents on scheduled services was, said Mr Ashton Hill, only 12 per cent. Mr Ashton Hill also asked Mr Milward whether BEA.13 (the chart showing BEA's estimate of the diversion of revenue if the applications were approved in full) was based on operation of 80-seater aircraft at the full frequency, and Mr Milward said that it was. Finally, Mr Milward was asked which he would prefer—a small diversion of traffic on a large number of routes, or the complete handing over of certain routes to the independents? The chairman likened this question to asking a man condemned to death whether he would rather be hanged or shot.

Next to cross-examine Mr Milward was Mr Porter, of Tradair, who suggested that ITX flights had so far had no effect on bilateral agreements, and Mr Milward agreed with this. Mr Porter also referred to Mr Milward's remarks about lowering of fares and asked whether, if the ITX applications of Tradair were approved, this would not mean that the traffic was being carried at the lowest fares available, and Mr Milward agreed with this also.

Questions From The Board

Questions from the Board to Mr Milward followed. He agreed that BEA maintained that they would be able to fill the full future demand allowing for growth of traffic at 10-15 per cent per annum. A member of the Board suggested that Mr Milward's objection to all the applications was inconsistent with the complimentary remarks he had made about Tradair. Mr Milward replied that he objected less to Tradair's applications than to the remainder.

The next witness for BEA was Sir George Cribbett, who gave evidence on the effects of bilateral agreements. Mr Marking first established his witness's status as an expert on such matters by questions about his former appointment as Deputy Secretary to the Ministry of Civil Aviation from 1946 to 1956 and his past and continuing associations with civil aviation, including deputy chairmanship of BOAC, and then asked him to comment on the principles and background governing the approach to bilateral agreements. Sir George Cribbett thought it inevitable that any introduction of a second British carrier on a route would be met by a stipulation that the first carrier's capacity be reduced. Any attempt to introduce a second British carrier into a number of countries at the same time would lead to concerted opposition. Sir George outlined the history of bilateral agreements and said that the principle of one route, one carrier, had been a cardinal principle of policy in the post-war years. All European bilateral agreements had been negotiated, like those with France, Greece and Portugal, on the basis of the assumption that there would be only one British carrier. The change to the policy of "fair and equal opportunity" had made little difference in foreign countries, where this was regarded as being synonymous with "equal capacity."

Sir George cited Italy and France as examples of countries where operation by two British carriers had caused unfavourable reactions. There had been difficulty in arranging traffic rights for both BEA and BOAC unless BEA were prepared to reduce their capacity in proportion to that offered by BOAC. In Italy there were consequent restrictions which unfavourably affected BEA.

Asked about the right of the national carrier to transport its own nationals, as had been suggested by counsel for BUA, Sir George said that this proposal had been raised at the Chicago conference of 1944 and had been overwhelmingly rejected.

Briefly cross-examined by counsel for BUA, Sir George maintained that any conditions specified in existing bilateral agreements would not be changed as a result of the Act of 1960. To a suggestion that the agreements might be re-negotiated, he said that this was a matter for H.M. Government to decide.

Cross-examined briefly by Mr Ashton Hill, Sir George agreed that he could speak with authority on Ministry affairs only up to 1956; but he was not ignorant about what had happened since. Re-examined by Mr Marking, Sir George said he did not rate very highly the possibility of re-negotiating bilaterals on terms more favourable to the UK. [*To be continued.*]

The first of five Convair 880-Ms to be delivered to Japan Air Lines has now been accepted and is being used to train JAL pilots at San Diego before flying to Tokyo. Two more will be delivered this month and two next spring; services are planned to begin on October 1

At Weybridge work is well advanced on mock-ups of the BAC One-Eleven. Spaciousness of the cabin of this 1964 jet successor to the Viscount is apparent from the left-hand picture; on the right is seen BAC's chief test pilot, Jock Bryce, who is playing a big role in laying out the flight deck, also now "mocked up"

AIR COMMERCE . . .

TWO ACCIDENTS IN 24 HOURS

A UNITED DC-8 and a CSA Il-18 crashed within 24 hours of each other on July 11, the former at Stapleton Airfield, Denver, Colorado, and the latter at Bouskoura, about nine miles south of Casablanca.

The Il-18 had been diverted to Casablanca from Rabat because of fog and was on finals when it hit some 60,000-volt high-tension cables, crashed and exploded. There was some uncertainty at first about the precise number of casualties, but official Moroccan sources said that the Il-18 carried 64 passengers and a crew of nine. There were no survivors. Among those killed were 24 Russian instructors on their way to train West African pilots; the Il-18 was on its way from Prague to Conakry, Guinea, and Bamako, Mali, on a regular CSA service. After striking the cables the aircraft, according to reports, slid 60 yards on its belly, overturned and exploded. The Il-18 is understood to have requested permission to land at the USAF base at Nouasseur, but a spokesman there said that the aircraft was still under the control of Casablanca when it crashed, and conditions at Nouasseur were below the accepted minima. According to the *Daily Express* there were two Czech pilots on board on their way to train pilots for Air Mali, also an Il-18 operator.

This was the second fatal accident to a Czech Il-18; one crashed near Nuremberg on March 28. The official Czech news agency Ceteka said, after three weeks of investigation by Czech aviation officials that the March disaster "occurred under very suspicious circumstances" and "outside interference" might have been a cause.

At least 30 people were killed when the United DC-8 caught fire on landing at Denver with 113 passengers and seven crew on board. The pilot had told passengers of a loss of hydraulic fluid, and warned them that fire engines would be along the runway; according to an eye-witness the landing gear buckled as the DC-8 touched down, and the aircraft swerved off the runway, crashed into a lorry and burst into flames. The lorry driver was killed. The DC-8 was *en route* to Los Angeles from Philadelphia, and had stopped at Chicago and Omaha. This is the fifth accident involving the write-off of a DC-8 since last December and the second to a United DC-8.

QUESTIONS IN THE HOUSE

MR. F. NOEL-BAKER asked the Minister last week to state the average number of minutes between the time that arriving passenger aircraft from abroad come to a standstill at London Airport and the completion of immigration formalities and the clearance by Customs of passengers and baggage. Mr Geoffrey Rippon, PPS to the Minister, replied that it took 35 minutes at the North terminal and less than 20 at the Central terminal. Mr Noel-Baker thought that this compared "appallingly badly" with other European airports, and quoted an average of 11 minutes for Copenhagen between touchdown and leaving the terminal building. Could not this procedure be speeded up for London Airport? Mr Chetwynd wanted to know whether any improvement would be made at the new long-haul terminal when it was ready. Mr Rippon did not think the times unreasonable, and thought that times at the new long-haul building should be better. Sir Arthur Harvey thought that the figures given were misleading, because at peak periods they were much worse at the Central building.

Mr Peyton asked if steps would be taken to improve arrangements for passenger handling at London Airport, and Mr Rippon confirmed that the new long-haul building would start being used this autumn; alterations to the short-haul building were in progress and an extension of accommodation for domestic flights had already been completed. Mr Peyton complained of the "slovenly and discourteous" handling of passengers, but Mr Snow thought that reception of passengers by Customs was a good deal better than in most parts of the world. Sir Arthur Harvey complained that passengers who arrive by taxi or private car have to take their baggage across the road in between moving vehicles; Mr Rippon promised to look into this.

Mr Rankin asked what financial support was being given to the development and production of the VC10. Mr Rippon answered that the Government had agreed to contribute towards the cost of launching the VC10, but it would be contrary to normal practice to give details of the terms of the contract.

Essentially the same answer was given to Mr Chetwynd when he asked how much money was received in rental for the site of the large whisky bottle advertisement at London Airport.

UP-TO-DATE WITH AIR LINKS

ALTHOUGH some people might think that the independents are interested mainly in taking over routes which the corporations have spent a lot of money developing, the recent activities of Air Links, the Gatwick-based independent, show that there is plenty of charter work for a small independent prepared to go out and find it, ranging from carrying live lobsters packed in dry ice to Brest to an airlift in the Spanish Sahara. Air Links' single Dakota was recently based in Las Palmas for a three-month contract for carrying oil company personnel, water, food and equipment to various geological and oil drilling camps in this part of the Sahara.

A six-monthly sub-contract has been awarded for the carriage of mixed freight between London Airport, Düsseldorf and Frankfurt "on behalf of a national airline," and group charter flights have been made to many destinations in Europe; notable among these are the carriage of motor racing fans to Le Mans and Grand Prix events. A second Dakota has now been acquired and Air Links hopes to operate internal services.

HOW TO GET ROUND IATA

A NEW Scandinavian charter company known as Scanair, in which SAS has a 45 per cent holding, came into being at the beginning of July and has its head office at Copenhagen. The remainder of Scanair's share capital is divided between Svenska Aeroplan Aktiebolaget (SAAB), the Danish East Asiatic shipping company, and the Norwegian shipping firm Mariana (Fearnley and Eger). Scanair is to lease four DC-7Cs from SAS and has already secured a number of tourist charter contracts, but according to *The Times* its formation has been criticized as "back door" admittance of SAS into the now flourishing charter market, to which the designated European flag carriers are now turning more and more.

SAS thus becomes the fifth such carrier in recent years to form or to take a financial interest in a previously formed independent airline to develop the charter markets and to find a use for surplus piston-engined equipment. It is in Germany that this significant new trend is most marked, for Lufthansa has recently bought up Condor Luftreederei and its two Convair 440s, and has increased its shareholding in Deutsche Flugdienst from 26 per cent in 1958 to 95 per cent in 1959 and 100 per cent in 1960. Two ex-Lufthansa L.1649A Starliners were added to the Flugdienst fleet some months ago, supplementing the four ex-KLM Convair 240s and two Vikings, while Flugdienst has ordered a Viscount 814 similar to those of

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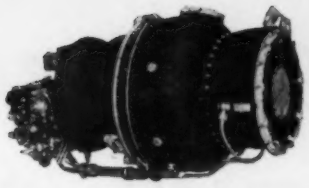

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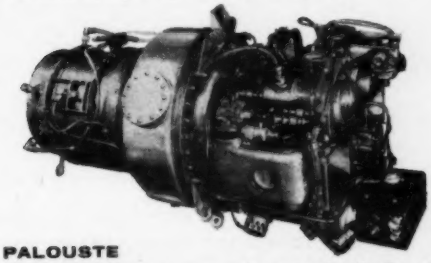

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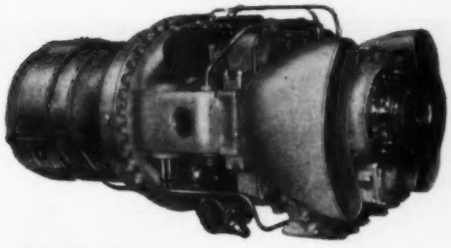

ARTOUSTE
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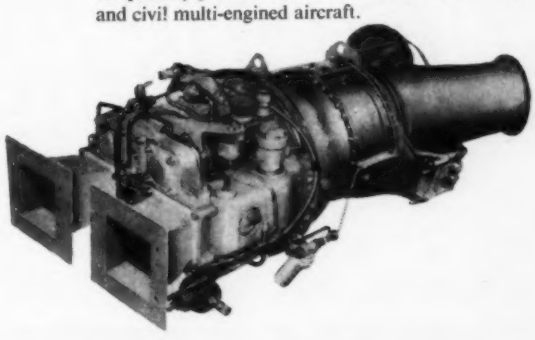

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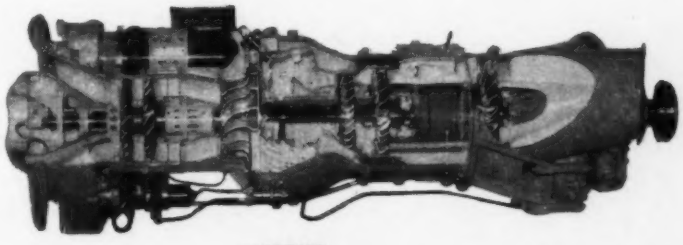

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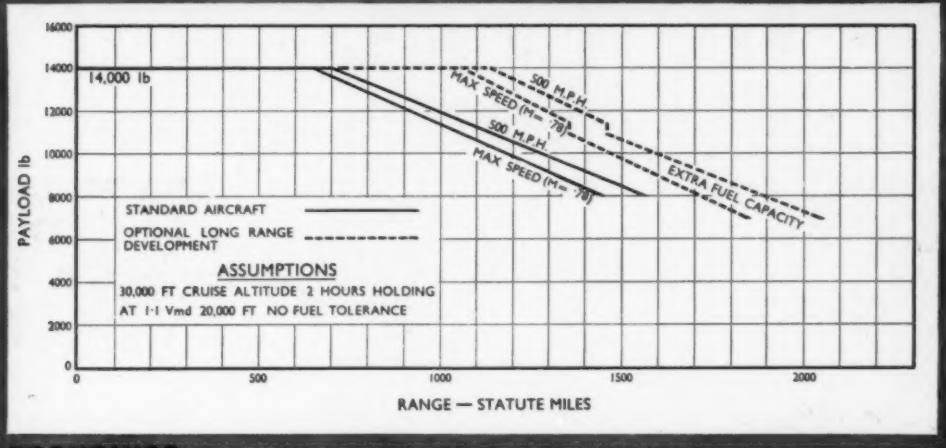
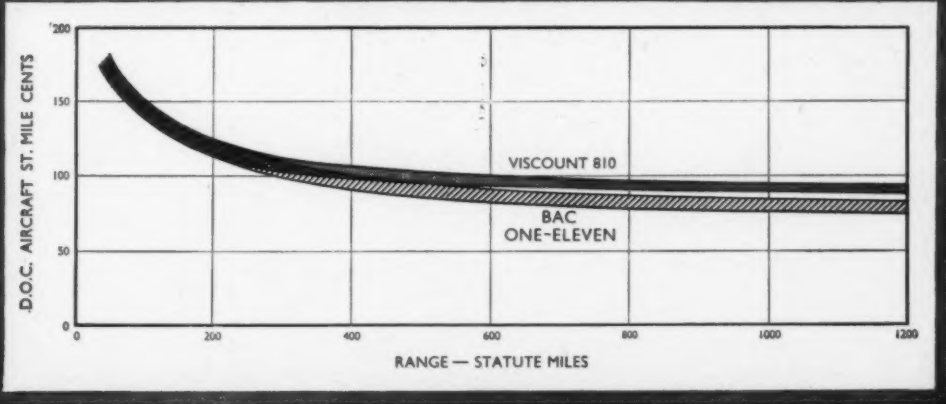


ECONOMICS



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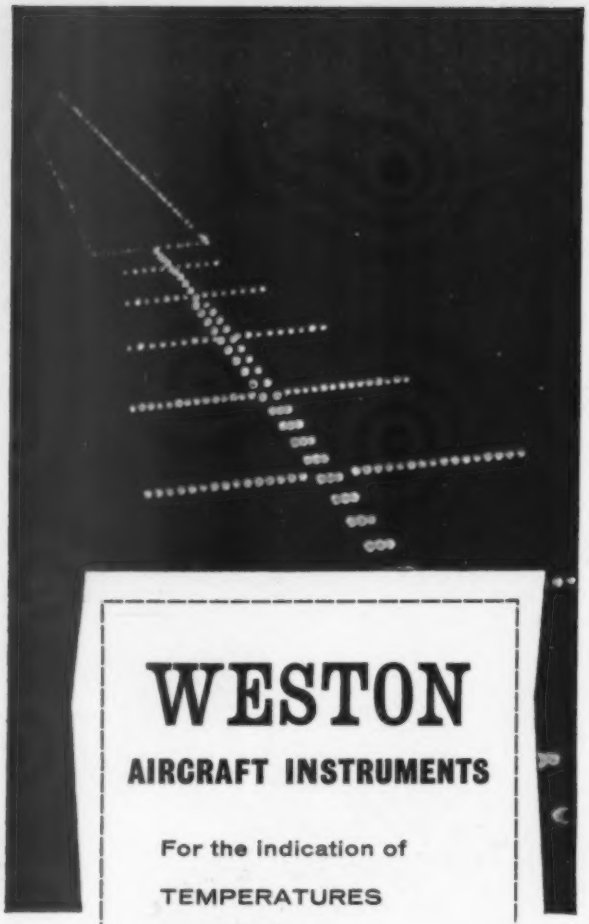

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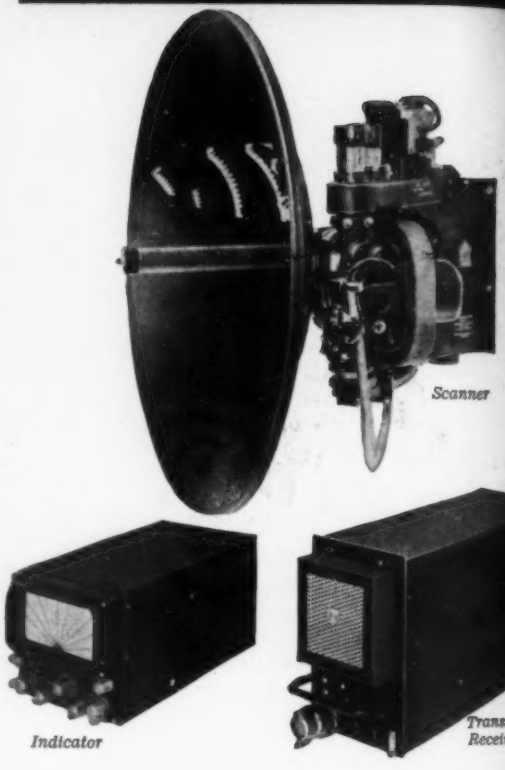

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WPS-363

Mr Macmillan, the Prime Minister, is seen here at the Soviet exhibition in London examining the big 40-seat Yak-24R, a turbine-engined successor to—but very much smaller than—the nine-seat Yak-24K. It is not clear whether or not the 24R is yet in being

AIR COMMERCE . . .

Lufthansa. Balair, in which Swissair has a 40 per cent interest and the Swiss Government 25 per cent, began long-haul charter flights with ex-Swissair DC-4s, while more recently Societa Aerea Mediterranea, a non-IATA charter affiliate of Alitalia, who own 90 per cent of its capital, started operations with two (now three) ex-Alitalia DC-6Bs and has booked about 350 inclusive tours between the UK and Italy for this season. Sobelair's association with Sabena, on the other hand, is of several years standing, and Sobelair, unlike the other charter affiliates, operates scheduled services (a domestic network in the Congo) as well as charter flights between Belgium and the Congo.

As *Flight* suggested in the October 2, 1959, issue, if IATA did not face up to the differential fare issue at Honolulu the inevitable forces of economics would tempt airlines—including IATA airlines—to find ways and means of using surplus propeller fleets at low fares outside IATA control, either by the formation of separate companies or by association with independents. This trend has been accentuated not only by the inadequacy of the propeller differential but also by the rapid outpacing of traffic by capacity as jet deliveries build up, until for some airlines, such as BOAC, excess of capacity is now a serious problem. Will the corporation follow SAS and Lufthansa in forming an affiliate for charter operations? If BOAC formed or acquired a charter affiliate to operate at non-IATA fares, it would inevitably lay itself open to the charge of undermining the established fare structure—a charge which BOAC and successive Ministers have found very useful in warding off independent low-fare competition. Again, if BOAC decided to acquire a holding in an independent airline as Lufthansa has done, there would be cries from the other independents of "They can't beat us, so they're joining us." It should, perhaps, be emphasized that the corporation at present has shown no intention of following SAS and Lufthansa in this trend.

EASTERN'S AIR SHUTTLE

DOUBTLESS inspired by the success of Allegheny's commuter services (described in our issue of May 27, 1960) Eastern has become the first of the US "big four" domestic trunks to put such services into operation. Over 35,000 passengers were carried on Eastern's air shuttle services between New York and Boston and New York and Washington from the inaugural flight on April 30 to June 8, and no less than 95.9 per cent of flights scheduled (1,075 out of 1,121) have departed on schedule. Eight 95-passenger L.1049C Super Constellations with galleys removed are permanently assigned to the operation, with 25 flight crews; extra aircraft of this type are on call for additional schedules if they are needed. A new air shuttle terminal costing $525,000 was opened on June 12; this is located in Eastern's hangar No 8 at the east end of La Guardia's road system, and is designed to demonstrate the greater efficiency and convenience of the "constant flow" principle of traffic handling in contrast to the present system where the passenger must pass through about half a dozen check points before he can board the aircraft.

Eastern's air shuttle services have attracted considerable interest—there have been reports of officials of competing airlines watching departures in an attempt to gauge load factors—and this type of service not only provides a use for obsolete piston-engined equipment but serves to convert highway users to air travel. What the passenger will appreciate most is the simplicity of this sort of service: like Allegheny's commuter services, no reservations, no tickets and no checking of baggage are necessary. The passenger pays for his journey on board, either cash down, with a so-called Flite-Chek, or by using his air travel credit card. On arrival at the air shuttle terminal, the passenger pulls a boarding pass out of the machine and signs his name and address (required for the manifest). When 95 boarding passes have been issued the flight is closed out, boarded and dispatched, and passes are issued right up to scheduled departure time. The passenger carries his bag to the boarding gate and puts it on the cart to be loaded on the aircraft, and luggage is delivered to a self-claim area at the other end, the aim being to get it there before the passenger does. Departures from New York, Boston and Washington are made at every even hour from 8 a.m. to 10 p.m. (fewer schedules are operated at weekends). Air shuttle fares are 27 per cent lower than standard first-class fares, and close to the rail fares.

BOAC STRIKE SPREADS

THE unofficial strike of BOAC electricians at London Airport had, as we went to press, spread to involve about 400 men, in spite of an appeal by the corporation's chief engineer, Mr Charles Abell, who gave three reasons why the stoppage was serious. "First, you will lose money. Second, our business this year has been very much worse than expected, and competition is stronger than it has ever been. Third, is this the time to damage BOAC when we are preparing our appeal against the Air Transport Licensing Board's decision to license another operator on the North Atlantic?"

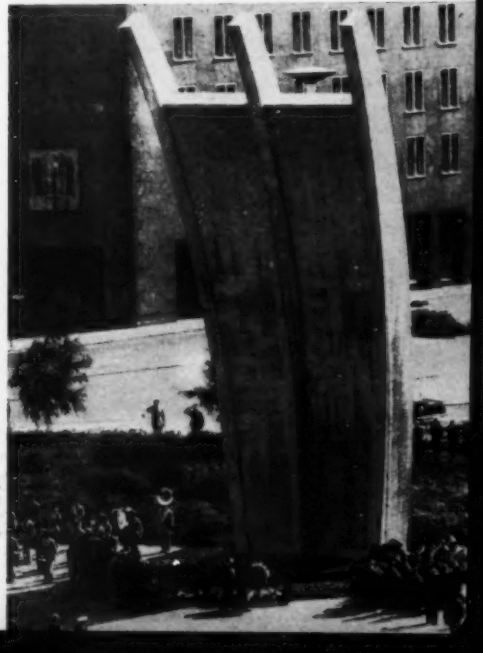
Mr Abell reminded the strikers that the new supervisory structure against which they had come out in protest was the last phase in a long-planned reorganization of the engineering department by which costs were being reduced.

AVRO 748 UNDER LOAD

GRATIFYING progress, it appears from a manufacturer's report, has been made with structural testing of the Avro 748, which has been under way since January 1960. In all these tests, which began with structural details and progressed to the testing of a complete fuselage, ultimate design loads were exceeded without failure. Initially, the strength of fuselage formers and floor beams under the severe loadings of the crash case were established, and then a wing section was tested to demonstrate the strength of a typical rib both before and after the rib had been artificially damaged. The latter case is an aspect of fail-safe testing.

The test programme then moved on to a specimen comprising an engine sub-frame and undercarriage mounted on the local wing structure, and engine and undercarriage loads representing seven design cases were applied, the results of which proved compliance with ARB requirements. Meanwhile a 748 fuselage complete with wings and tailplane had been assembled for static testing, and tests on this specimen began in April. One of the wing tanks was sealed and loads were applied with this tank in the full fuel condition. The landing case was cleared satisfactorily and in June the 66ft per second gust loading case was tested. This case controls the wing bending moment and design of most of the front fuselage, and loading in this case was increased to 103 per cent of the ultimate design load without failure. The specimen will shortly be tested to destruction.

Last August the cabin was pressure-tested in a new water test tank at the main Avro works. This test specimen was pressurized to a cabin differential of 12.1 lb/sq in, or considerably more than twice the working pressure required. During the test schedule the fuselage withstood over 10,000 pressurization cycles. A complete airframe has now been installed in the water test tank and will shortly be fatigue-tested to destruction. This programme, when complete, will determine the Avro 748's fatigue life and fail-safe properties.



The memorial in West Berlin to the 1948-49 airlift, of which British air transport has many memories, was the scene of a ceremony this month to commemorate the twelfth anniversary of the operation—a ceremony having more than usual significance this year. The memorial honours the 70 American and British aircrew who died during the airlift

AIR COMMERCE . . .

A new picture taken recently at Warsaw Okecie Airport of one of LOT's Ilyushin Il-18s. A "Flight" staff member recently visited the airline, and we hope to publish his report in an early issue

NAC LOOKS BACK

ALTHOUGH it may appear a little late to be reviewing the annual report of an airline which closed its accounts as long ago as March 1960, when that airline happens to be New Zealand's National Airways Corporation the exercise is well worth while, for these Antipodean accounts are rare visitors to Britain's shores.

The corporation is one of those unfortunate airlines whose economic health hangs on that precarious balance known as a high load factor: in the case of NAC anything less than 75 per cent is cause for anxiety. In 1959-60 the achieved factor fell to 72 per cent and the airline only just scraped through with a scant £11,000 net profit on revenues of £4.3m. The misfortunes attending Wellington's new airport, Rongatai, also had a damaging effect on NAC's finances. Not only was the opening on a full-time basis delayed from early in the year until as late as November, but in the first month of full operation unusually adverse weather—"unparalleled in the preceding 20 years"—severely disrupted services at a busy period.

Traffic on routes operated by the corporation's three Viscounts (a fourth has now been delivered) showed the remarkable increase —over a third—which has become an accepted part of the Viscount tradition. But the bulk of the revenue was still earned by NAC's fleet of twenty-six DC-3s. For a short-haul airline (average passenger haul, 262 miles), the fleet achieved remarkably high annual utilization rates (Viscounts, 2,400hr; DC-3s, over 1,800hr). The principal factor enabling these levels to be reached was the relatively even flow of traffic throughout the year. Instead of the dramatic summer peak/winter trough which is typical of so many airlines, a triple traffic-peak (May, August/September and January) is characteristic of NAC. This, of course, not only allows above-average utilization rates to be maintained, but also helps in keeping down overheads generally.

Another advantage enjoyed by NAC is its monopoly of domestic trunk services. It is this which allows the corporation to maintain its vital high load factors and also to depreciate its fleet at relatively gentle rates.

Although NAC carried as many as 650,000 passengers in 1959-60, it remained a surprisingly compact airline, with its route mileage standing at only 3,459 and its workforce at the year-end being less than 2,000. The main unit in the organization was the engineering and stores base at Christchurch, which employed 652. By contrast, the headquarters at Wellington employed only 161. The balance consisted of 226 aircrew and 884 other staff stationed at branch offices and outstations through the two islands.

BREVITIES

A Curtiss CW-20T Commuter (C-46) of Transcontinental SA crashed at Buenos Aires on June 30, killing 21 of the 31 passengers and two of the four crew.

The Ministry has decided to hand over to the airlines responsibility for apron-servicing at London Heathrow Central from April 1. This has been the practice at the North terminal for some years.

As this issue goes to press it is announced by IATA that European fares will go up five per cent on November 1. The last time there was a reduction in basic European fares was in 1953.

Talks between America and Russia regarding New York - Moscow air services are to open in Washington on July 18. The US delegation will include PanAm observers.

A Tu-114, in a 1hr 22min flight from Moscow Vnukovo on July 12, reached 12,535m (more than 41,000ft) with a payload of 30,035kg (over 66,000lb). The pilot was Capt Ivan Sukhomlin. A world record is being claimed.

New York Idlewild handled 2,820,649 international passengers in 1960, an increase of 18.2 per cent over 1959. The three New York airports together—Idlewild, La Guardia and Newark—handled 13,320,558 passengers, an increase of only 1 per cent on the previous year's figure.

The Minister of Aviation is soon to invite tenders for a new £750,000 luxury hotel at Prestwick.

Interavia Air Letter reports that Sabena has placed a repeat order for two Boeing 707-329s, bringing their 707 fleet up to six, and that Air France is negotiating with Boeing for up to five Model 707-320Bs.

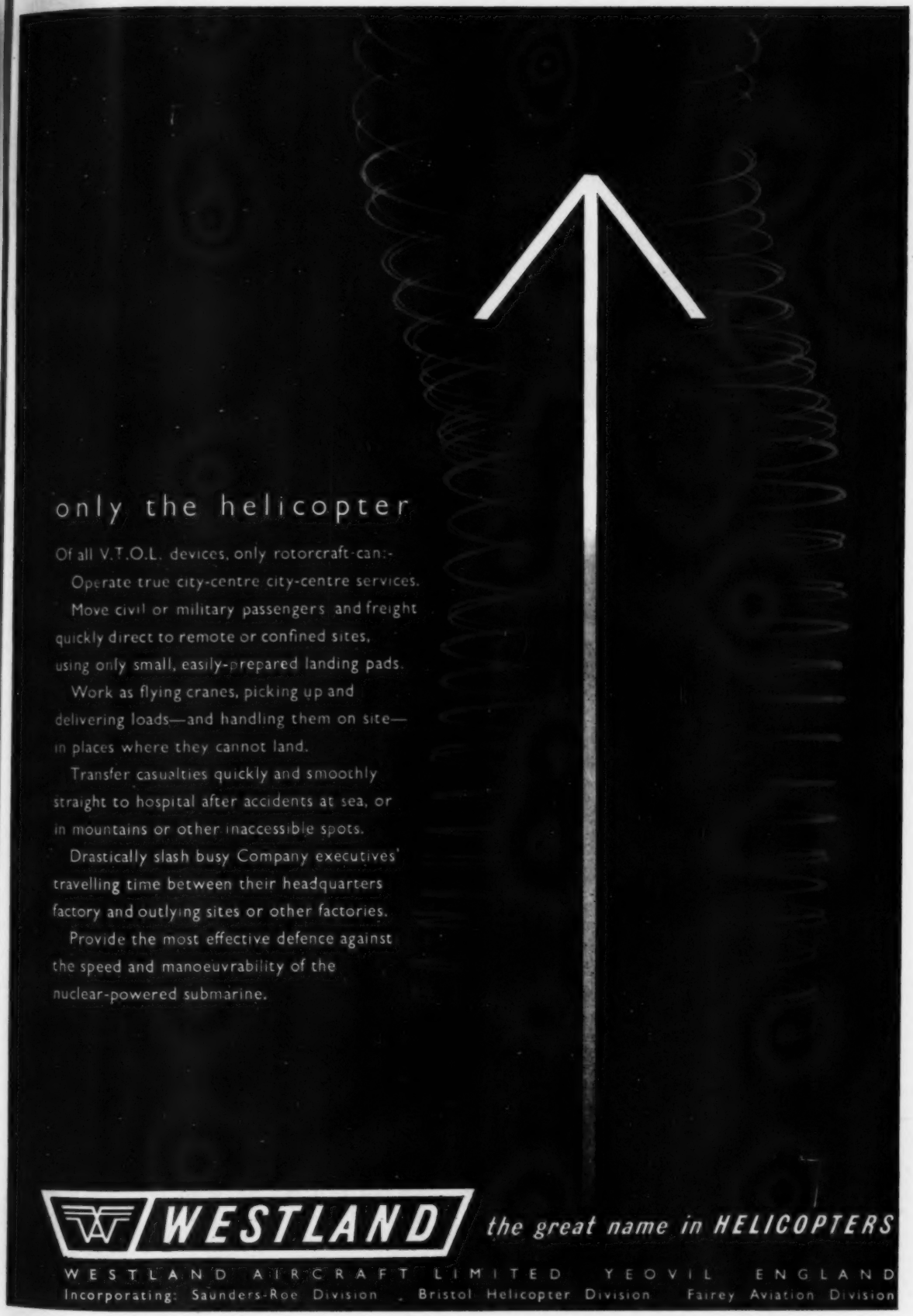
The FAA has granted a provisional airworthiness certificate to the Vertol 107. The first production aircraft, which flew on May 19, is undergoing FAA tests with two other pre-production 107s. The prototype, which flew in 1958, is at present on its second tour of Western Europe.

Maj Yuri Gagarin took the right-hand seat of the BEA Viscount (Capt Stanley Key) in which he flew last week from London to Manchester. After the flight Capt Key said: "Maj Gagarin told me how pleased he was to have had the opportunity to come up front. He also seemed very interested in the navigation instruments [Decca] which were tracing our flight-path on the moving map in the cockpit."

Starways have applied to the ATLB for a series of hovercraft ferry services across the Mersey, the Thames, and from Canvey Island; across the Severn; from Liverpool to the I of M, Belfast and Dublin; from Glasgow to Belfast; to the I of W from Portsmouth, Southampton and Bournemouth; to the Channel Isles from Southampton; from Newquay to the Scillies; Dover-Calais; and Harwich-Rotterdam-Antwerp. Skyways plan to have a fleet of 14 100/150-seat hovercraft, and are discussing orders with two constructors.

The appeal by Falcon Airways to the Minister of Aviation against conditions in their air operator's certificate (*Flight* last week, page 59) was withdrawn before the hearing, due on July 12, took place. On July 15 the Ministry banned a Falcon Airways flight from Gatwick by a Constellation said to be owned by Aero Transport of Austria. Mr Frederick Beezley of Falcon is quoted as saying: "I think this is one more step in [the Ministry's] vendetta against Capt Kozubski. I think certain officials of the Ministry of Aviation have a personal dislike of Capt Kozubski and myself. I have come to the conclusion that if you join him, then you must expect the Ministry to be your enemy."

A British United Airways Whirlwind takes off from an oil drilling rig during summer storm conditions in the Persian Gulf. This helicopter, one of BUA's fleet of three engaged in off-shore drilling in the Gulf, is based at Khosrovabad near Abadan. It was announced last week that BUA have bought the helicopter unit of Christian Salvesen & Co Ltd whose three Whirlwinds will now operate from BUA's helicopter base at Redhill. The BUA helicopter fleet now comprises 16 Whirlwinds, four Widgeons, seven Bells and 23 Hillers. Last May the company ordered six new Hiller 12Es



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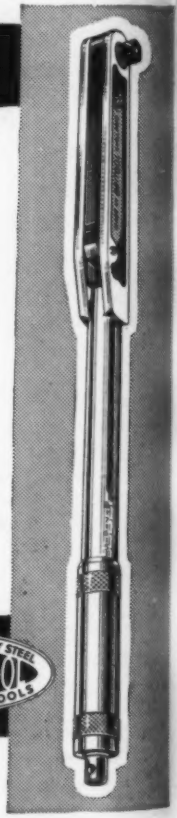

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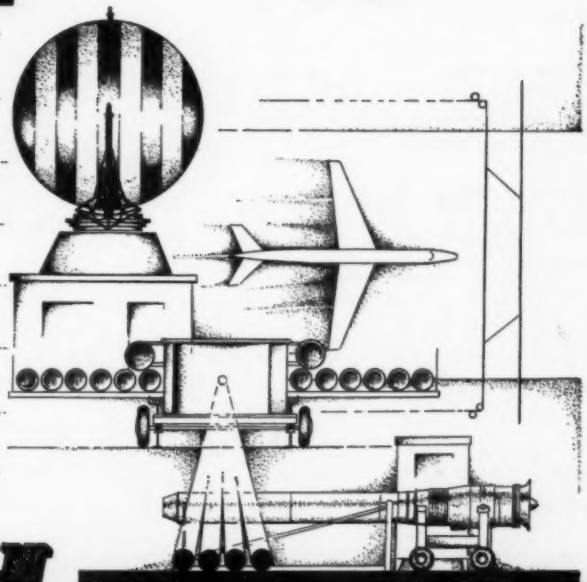

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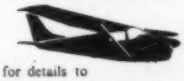

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COMMONWEALTH OF AUSTRALIA

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